AD-A088 155 FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE--ETC F/G 1/2
THE EFFECT OF WHISPER/SHOUT ON ACTIVE BCAS PERFORMANCE,(U)
JUN 80 E J KOENKE, S BOCZENOWSKI
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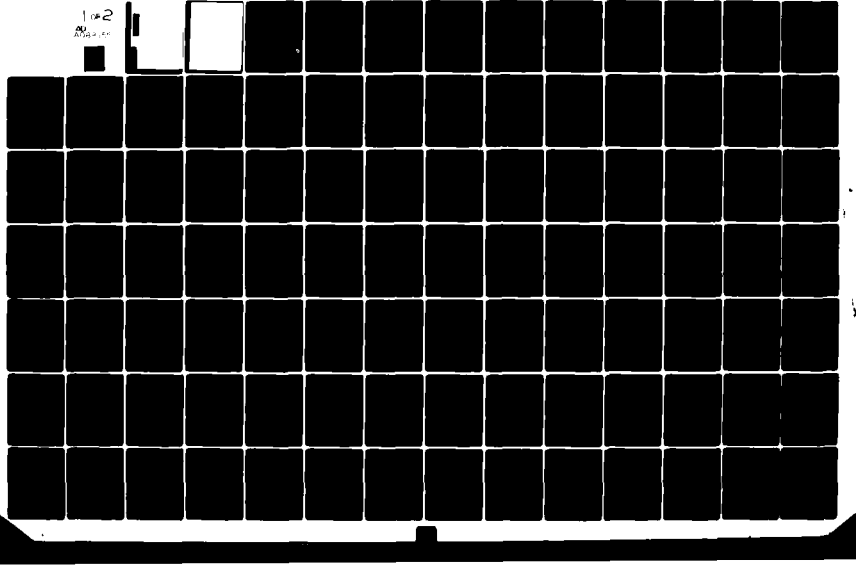

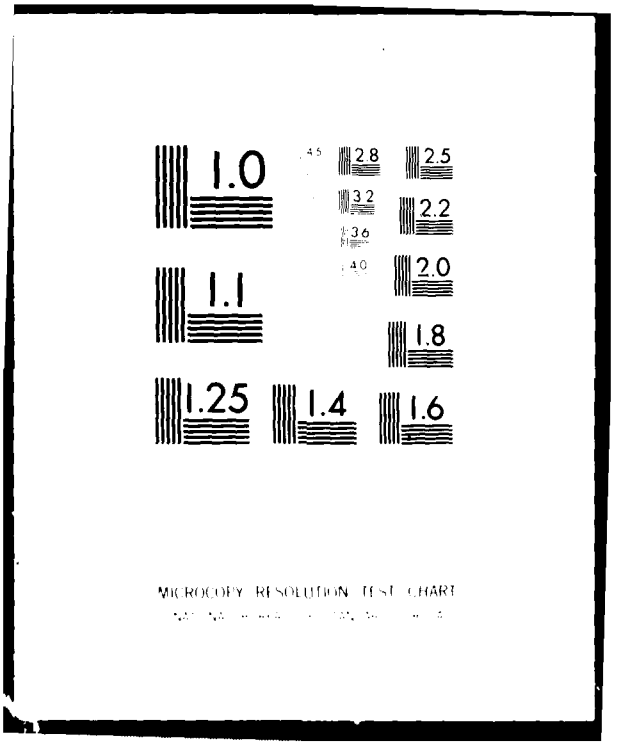
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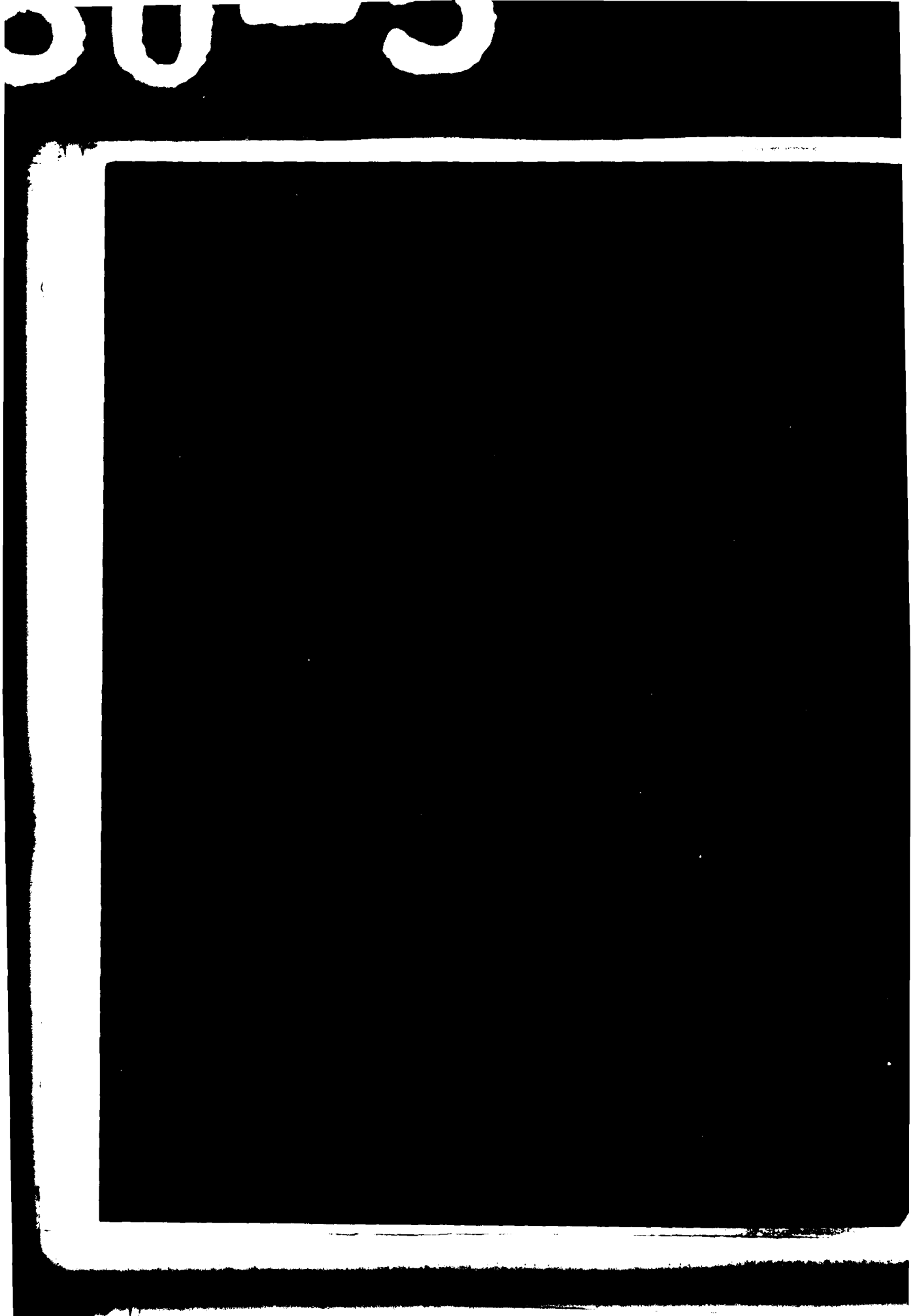

$$S_2 = P_1 \times P_2 \times P_3$$

Technical Report Documentation Page

1. Report No. (14) FAA-EM-80-5	2. Government Accession No. AD-A088 755	3. Recipient's Catalog No. (11)
4. Title and Subtitle (6) The Effect of Whisper/Shout on Active BCAS Performance (12) 111		5. Report Date
		6. Performing Organization Code AEM-200
7. Author(s) (10) ~~Dr.~~ Edmund J. Koenke, Sandra Boczenowski		8. Performing Organization Report No. FAA-EM-80-5
9. Performing Organization Name and Address Federal Aviation Administration Office of Systems Engineering Management 800 Independence Avenue, S. W. Washington, D. C. 20591		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Same as above.		13. Type of Report and Period Covered
		14. Sponsoring Agency Code AEM
15. Supplementary Notes		

16. Abstract

When BCAS is operating in a high density environment the presence of synchronous garble will interfere with target detection. This report presents a simulation tool used to analyze the BCAS operation in a garble environment with several design variations. The chief BCAS enhancement evaluated was the technique known as whisper/shout. This technique can effectively reduce the garble problem when a BCAS aircraft operates in terminal airspace. In addition, the effectiveness of degarble capabilities is demonstrated in various airspace densities. A low cost general aviation CAS is evaluated with the same model and performs well in terminal airspace.

It is concluded that in order to satisfy the draft U. S. National Aviation Standard for BCAS that a system must use full degarbling, whisper/shout and at least a 1-second update rate.

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17. Key Words BCAS, Active BCAS, Garble, Collision Avoidance, Threat Acquisition, Whisper/Shout	18. Distribution Statement		
19. Security Classif. (of this report) UNCLAS	20. Security Classif. (of this page) UNCLAS	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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THE EFFECT OF WHISPER/SHOUT ON ACTIVE BCAS PERFORMANCE

INTRODUCTION

Operation of an active Beacon Collision Avoidance System (BCAS) in a high-density environment can result in degraded performance due to synchronous garble. The garble phenomenon is encountered when BCAS receives overlapping replies to an ATCRBS Mode C interrogation. Successful target detection is critical to BCAS before any tracking, threat detection, or evasive maneuvers can be accomplished. This report presents the development of a mathematical model to evaluate the whisper/shout technique as an improvement to the BCAS design. The model is used to estimate the effectiveness of whisper/shout in reducing the occurrence of overlapping replies. Whisper/shout is evaluated with varying degarble capability, interrogation rates, aircraft densities, and threat closure rates. The model is also used to evaluate the target acquisition capability of a low cost general aviation collision avoidance system.

APPROACH TO WHISPER/SHOUT

Whisper/shout was designed to reduce the effect of synchronous garble in high-density airspace. (See Reference 1.) The technique takes advantage of the variance in receiver sensitivity among the transponder equipped aircraft population. During a single BCAS epoch, several suppression requests are interspersed with the interrogations. These suppression requests force aircraft that have previously answered an interrogation to be prohibited from replying until the following epoch. The pattern of interrogations and suppressions is the key to reducing the number of overlapping replies.

A complete exercise of a BCAS whisper/shout epoch is shown here to illustrate how it functions in reducing total replies to any one interrogation. The BCAS interrogator will use a low power initially to trigger replies from aircraft close in range and those with high receiver sensitivity. After waiting a nominal time period (100 μsec) for replies, BCAS will send a suppression pulse pair, P2 pulse greater than or equal to P1, at a power 2db below the previous interrogation. The suppression pulse pair forces those aircraft which have already replied to be prohibited from replying for 35 μsec. The 2db power reduction lowers the chance of suppressing an aircraft whose receiver is on the border of the sensitivity range, and has not replied to the first interrogation. During the 35 μsec lockout BCAS sends another interrogation 6db higher than the first one and waits a longer time (150 μsec) for the surrounding aircraft to reply since a greater range will be reached. The cycle between suppress/reply requests is repeated for several iterations (in this simulation 4 and 5 interrogations were used) until the power for the last interrogation is set at the system's maximum. Each time the BCAS aircraft requests a reply some of the aircraft in its maximum range will not answer, either due to inability to detect a request or due to a suppression.

At the next epoch BCAS begins again with an interrogation at the low power level. Since no suppression pulse precedes it, all aircraft that "hear" the interrogation are able to reply. Reduction of replies in each epoch decreases the effect of synchronous garble.

The approach used to verify that whisper/shout enhances target acquisition capability was based on the simulation designed to test the performance of an active BCAS in a garble environment (Reference 2). The whisper/shout method made use of four interrogations during each BCAS epoch. The following power levels were used in the simulation for the interrogation and suppression requests:

Interrogation	39 dbm	45 dbm	51 dbm	57 dbm
Suppression		37 dbm	43 dbm	49 dbm

An interrogation is considered successful when the BCAS transmits the request, the target aircraft receives the request and replies to it, and the BCAS aircraft "hears" the reply. This link reliability is determined using the diversity antenna (BCAS equipage) vs. the single antenna (all other equipage) curve from Figure 1. The relationship between link margin and link reliability is described in Reference 3.

The reliability is essentially a function of the range, transmitter power and the receiver sensitivity. Assuming that the probability of an interrogation by the BCAS aircraft and a reply from any aircraft have independent likelihoods of success, the round trip reliability can be given as the product of the probabilities of two successful transmit-receive operations. Suppression depends on the BCAS

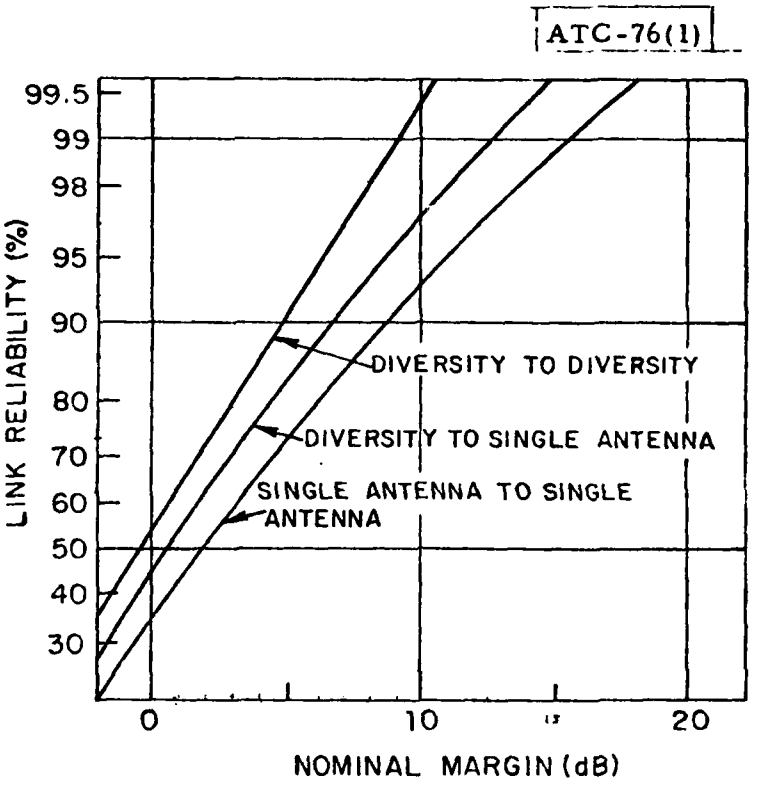


Fig. 1. RF Power and Sensitivity Effects

transmitting its request and the aircraft receiving it, which is a one-way link. The suppression reliability is therefore taken as the square root of the round reliability:

$$Ps = \sqrt{PL}$$

At each whisper/shout power level used, the likelihood that BCAS receives a single reply at that power level depends on three criteria. One is that the aircraft is in the specified range differential from the BCAS aircraft (defined in Reference 1). Second is that the aircraft "hear" the interrogation, reply, and BCAS "hears" the reply. Third is the probability that the aircraft was not previously suppressed by a BCAS request in that epoch.

The probability that the aircraft is in the range differential is given by equation 1 in Reference 1 as:

$$Pe = 4dR \times R / R^2$$

The probability of a complete interrogation-reply is taken from Figure 1, and the likelihood of a reply being unsuppressed is given by:

$$Pu = 1. - \sqrt{PL}$$

The probability of an aircraft being in the annulus and BCAS detection of a reply is given by:

$$Pd = Pe \times PL \times Pu$$

Using this probability the binomial thoerem can be employed to determine the likelihood of BCAS detecting exactly K aircraft in the desired region. This probability is given by the binomial distribution as:

$$Pk = \binom{n}{k} Pd^k \times (1 - Pd)^{n-k}$$

The whisper/shout technique is tested for its effectiveness in a garble environment. The degarbling capability is assumed to be effective with a probability of G1 for the first overlap and G2 for the next Any further overlap of replies is assumed to be impossible to degarble. Using these values the probability that BCAS can successfully detect aircraft in a garble situation during a single interrogation attempt is given by:

$$Pk(i) = PL \times Pu \times (1 \quad Pd)^n +$$
$$Nx\ Pd \times (1 - Pd)^{n-1} \times G1 +$$
$$Nx(N\ 1)/2 \times Pd^2 \times (1 - Pd)^{n-2} \times G2$$

i = number of whisper/shout levels

After all of the whisper/shout attempts have been made in that epoch, the probability of BCAS "hearing" a clear reply is based on the likelihood of detection at any one of the power levels. Success in one BCAS epoch is given by:

$$P = 1 - \quad ((1 \quad Pk(1)) \times (1 - Pk(2)) \times \ldots$$

$$x\ (1 - Pk(i\ 1)) \times (1 - Pk(i)))$$

i = number of whisper/shout levels.

As the threat aircraft approaches the BCAS aircraft the probability of a successful reply will increase. The likelihood of a reply is a function of the link reliability and at closer ranges the link margin will increase. In the simulation the threat aircraft were positioned at the system's maximum range and flown towards the BCAS aircraft at a fixed speed. As the time to collision approaches zero, each successive epoch will have an increased likelihood of a reply. The whisper/shout analysis is compared to an analysis in the same garble environment with a fixed interrogation power of 57 DBm.

THREAT ACQUISITION PROBABILITY

The simulation tool developed in Reference 2 to analyze target acquisition was time based. A fixed number of epochs, time to collision, was allowed for the BCAS aircraft to obtain the minimum number of replies for successful acquisition before coordinating maneuvers. The purpose of this analysis is to evaluate the effects of the system design on target acquisition in a variety of aircraft densities. The number of epochs allowed for target acquisition in the simulation is based on maximum system range. Each of the closure rates between the BCAS and threat aircraft determine the time to collision which is given by:

$$TAU = SYSTEM\ RANGE \times 3600 / SPEED(KNOTS)$$

For purposes of this analysis, the simulation is started at the tau calculated for the system range and the aircraft flown until tau reaches zero.

Successful target acquisition was defined in this simulation as the BCAS aircraft receiving three consecutive replies out of M BCAS interrogations. Using the Monte Carlo simulation from Reference 2, target acquisition with whisper/shout was tested for five closure rates: 250 knots, 500, 750, 1000, and 1250 at a 1-second update rate. This technique required 20,000 trials at each of 583 position configurations. The time involved in running all desired cases with various aircraft densities and degarble capabilities in a Monte Carlo analysis proved to be prohibitive. The alternative of generating a closed form equation for the threat acquisition probability was explored with a tree analysis (Reference 4) as shown in Figure 2.

When BCAS interrogates for the minimum of three trials, there is only one way to achieve successful target acquisition. Assuming that each

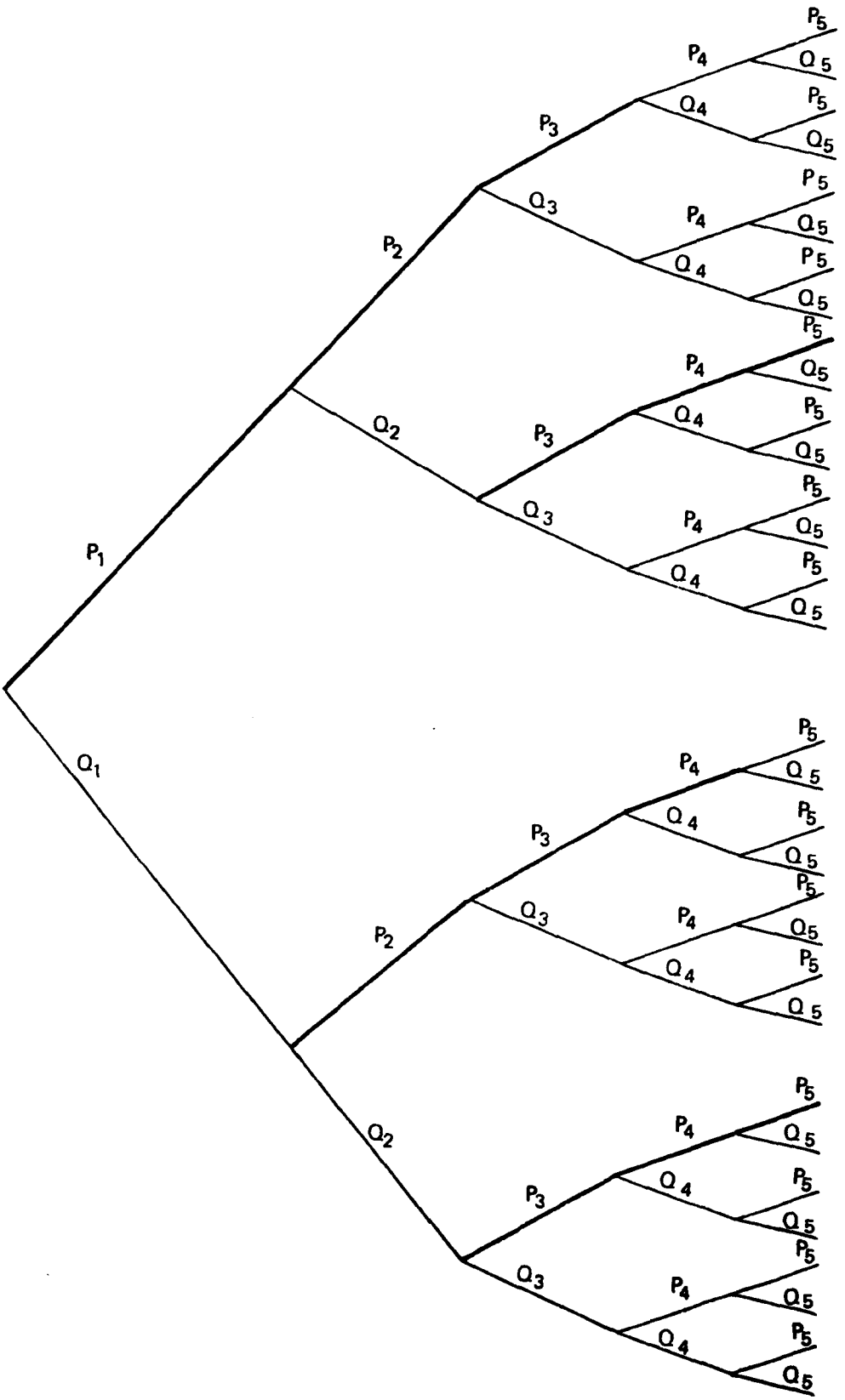


Figure 2. Threat Acquisition Probability Tree

interrogation-reply trial is an independent event, the probability of success in only three epochs is given by:

$$P1 \times P2 \times P3$$

Each time that BCAS fails to "hear" a reply three additional trials must be made to achieve threat acquisition, and the probability is given by:

$$(1 - P_{i-3}) \times P_{i-2} \times P_{i-1} \times P_{i}$$

where i = current trial number

As continued trials are attempted the equation for successful target acquisition at each epoch i must allow for the failure to achieve a previous set of three successful replies. If the acquisition had already succeeded, further trials would not be attempted This probability is given by:

$$1 \quad (P_{k-2} \times P_{k-1} \times P_{k})$$

where k = i-4

The seventh epoch is the first one where this probability must become a part of the general formula as shown:

$$S_7 = (1 - P_1 \times P_2 \times P_3) \times (1 - P_4) \times P_5 \times P_6 \times P_7$$

As the number of trials increases, the acquisition equation uses each previously possible success combination and assumes its failure to justify the continuing attempts to acquire three consecutive replies. The general form for the equation is then:

$$S = (1 - P_{i\,3}) \times (P_{i\,2} \times P_{i-1} \times P_{i}) \times \left(1 - \sum_{k=3}^{i-4} S_k\right)$$

See table 1 for the expansion of this equation for eleven epochs.

$$S_3 = P_1 \times P_2 \times P_3$$

$$S_4 = (1 - P_1) \times P_2 \times P_3 \times P_4$$

$$S_5 = (1 - P_2) \times P_3 \times P_4 \times P_5$$

$$S_6 = (1 - P_3) \times P_4 \times P_5 \times P_6$$

$$S_7 = (1 - P_4) \times P_5 \times P_6 \times P_7 \times (1 - S_3)$$

$$S_8 = (1 - P_5) \times P_6 \times P_7 \times P_8 \times (1 - S_3 - S_4)$$

$$S_9 = (1 - P_6) \times P_7 \times P_8 \times P_9 \times (1 - S_3 - S_4 - S_5)$$

$$S_{10} = (1 - P_7) \times P_8 \times P_9 \times P_{10} \times (1 - S_3 - S_4 - S_5 - S_6)$$

$$S_{11} = (1 - P_8) \times P_9 \times P_{10} \times P_{11} \times (1 - S_3 - S_4 - S_5 - S_6 - S_7)$$

TABLE 1 Probability of three consecutive replies

The likelihood of success at an epoch i is a mutually exclusive event from a success at epoch i+1, because after successful threat acquisition further trials would not be necessary. The probability of success at epoch i is therefore the union of all possible successes from the third trial up to epoch i, and is given by:

$$P = \sum_{i=3}^{i=\text{max no. of epochs}} S_i$$

Since this equation calculates the probabilities directly, computer processing time could be reduced significantly over a Monte Carlo analysis. To verify the technique the resulting probabilities were compared to those obtained in the Monte Carlo analysis. Table 2 shows a comparison between the techniques when whisper/shout is used with 80%/60% degarble for a closure rate of 1000 knots at a 1-second update rate. The mean difference between the techniques was .0022 and the peak difference was .00707 using the represented values. All of the curves presented in Appendix 2 were run using the closed form algorithm.

TAU	CLOSED FORM	MONTE CARLO
47	.06010	.05870
46	.10152	.10005
45	.14636	.14275
44	.19441	.19055
43	.24028	.23570
42	.28592	.27885
41	.33104	.32855
40	.37531	.37385
39	.41870	.41840
38	.46105	.46055
37	.50220	.50320
36	.54119	.53970
35	.57814	.57575
34	.61316	.61115
33	.64788	.64680
32	.68131	.68255
31	.71317	.71740
30	.74309	.74555
29	.77100	.77330
28	.79697	.79820
27	.82096	.82185
26	.84287	.84480
25	.86435	.86261

TABLE 2 Comparison of Closed Form Equation and Monte Carlo methods (aircraft density .02, closure rate 1000 kts, whisper/shout and 80%/60% degarble capability)

DESIGN TRADEOFFS

The active BCAS target acquisition performance depends on aircraft density, closure rates, system range, transmitter power, interrogation rates, and degarble capability. In the simulation the following cases were tested:

Density was varied from 5 to 30 aircraft
in a 20-mile radius

Closure rates were varied
from 250 to 1250 knots for BCAS
and from 100 to 600 knots for G/A CAS

System range was set at
28 nms. for BCAS with a maximum transmitter power of 62 dbm.
18 nms. for BCAS with a maximum transmitter power of 57 dbm.
10 nms. for the general aviation CAS

Transmitter power was set at
62 dbm for BCAS with 5 whisper/shout levels
57 dbm for BCAS with 4 whisper/shout levels
50 dbm for general aviation CAS

Interrogation rates were tested with 1-second
and 3-second epochs

Whisper/Shout was tested with four interrogations:

INT	39 dbm	45 dbm	51 dbm	57 dbm
SUP		37 dbm	43 dbm	49 dbm

and five interrogations:

INT	39 dbm	45 dbm	51 dbm	57 dbm	62 dbm
SUP		37 dbm	43 dbm	49 dbm	55 dbm

Three levels of degarble capability were implemented with the whisper/shout algorithm. First, the full degarble capability using pulse width determination was used, which according to empirical values could obtain a clear reply 80% of the time with one overlap and 60% of the time with two overlaps. Second, a system with deinterleaving was used which could obtain a clear reply 55% of the time with one overlap, but 0% of the time with two overlaps. The third method assumed that there was no degarble capability.

Whisper/shout was implemented on all system designs except for the general aviation CAS. The four interrogation whisper/shout design, using the varied degarble capabilities, was compared to the same densities and closure rates on a system with one interrogation per epoch at a transmit power of 57 dbm. In addition, the whisper/shout technique was run with a fifth level of interrogation, at a higher power, to assess any significant change in target acquisition.

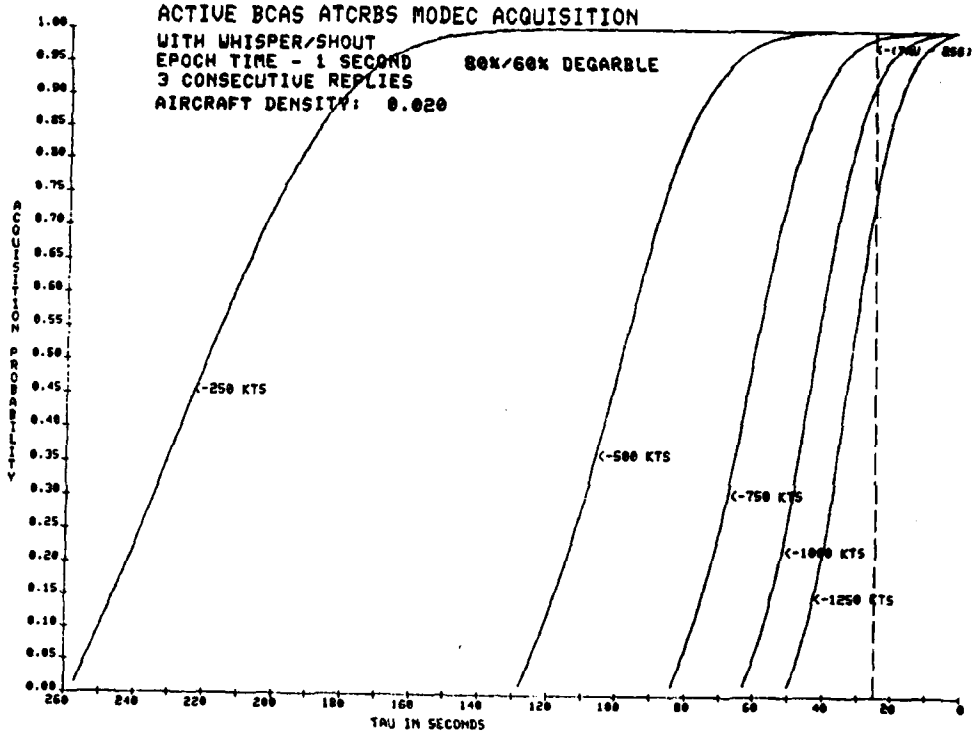
The general aviation CAS was run with a full degarble capability, and no whisper/shout capability. This system had a lower transmitter power, and the system range tested was only 10 and 15 miles. The density was assumed to be approximately 20 aircraft in a 20-mile radius. Because the general aviation system was designed for lower performance aircraft, the closure rates used in the simulation were limited to 100-600 kts.

RESULTS

This study explored the effects of three major parameters in a BCAS design. The results of varying interrogation rate(epoch length), degarble capability, and addition of the whisper/shout technique are discussed in this section. All system designs are examined from the time a threat aircraft is at the system's maximum range until time to collision reaches zero, and the graphs are presented in Appendix 2. Tau at 25 seconds was chosen to point out major effects of variations in the BCAS designs, because avoidance command posting should be accomplished at this time.

BCAS epoch length has a significant impact on the system target acquisition capability. Target acquisition probability is the likelihood of successfully decoding three consecutive Mode C replies by the time the target reaches tau. Figure 3 presents two plots of target acquisition probabilities in a terminal area environment, at a density of 0.02 aircraft/nm^2 at closure rates ranging from 250 kts to 1250 kts. These graphs illustrate the decrease in capability with a less frequent interrogation by comparing systems with full degarble and whisper/shout, but a 1-second and 3-second epoch length. When time to collision reaches 25 seconds, acquisition probability for the 1-second epoch approaches 100%, but the probability for the 3-second epoch falls to 95% in terminal area head-on encounters (closure rate of 500 kts).

Although the density is lower in enroute airspace, the higher closure rates in head-on encounters will result in greater performance degradations with a 3-second epoch length. Figure 4 compares epoch lengths of one second and three seconds in a .012 aircraft/nm^2 density. At a closure rate of 500 kts the 3-second epoch will have a 98% probability of successful target acquisition, but head-on encounters at a closure rate of 1250 kts have only a 53% chance of successful acquisition by 25 seconds before collision. In contrast, the encounters at 1250 kts with a 1-second update rate will produce a 93% chance of success at tau equal to 25 seconds.



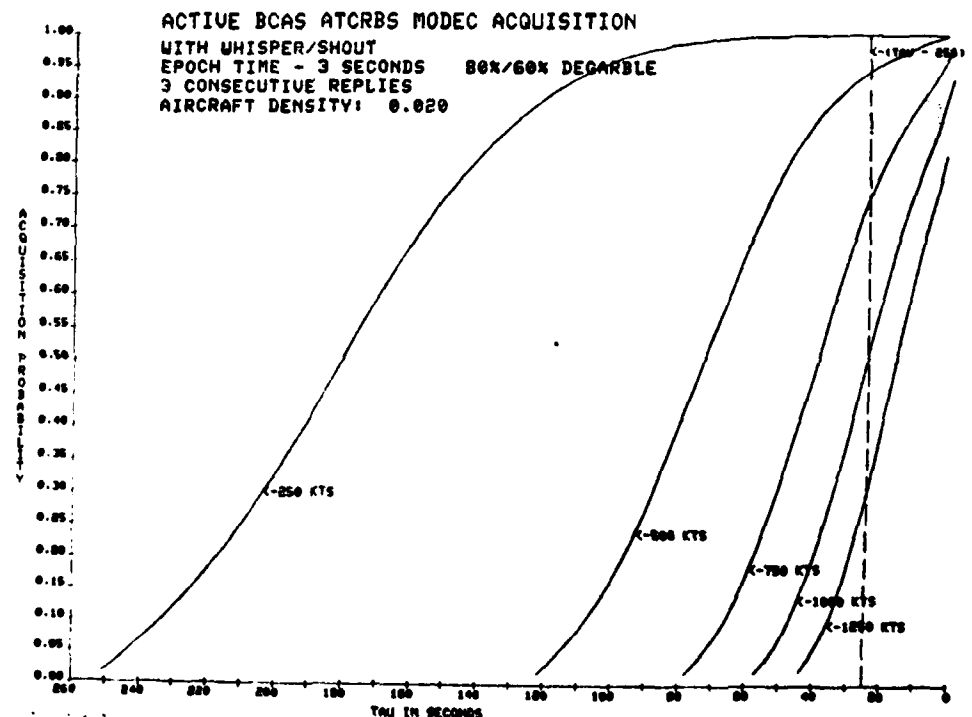
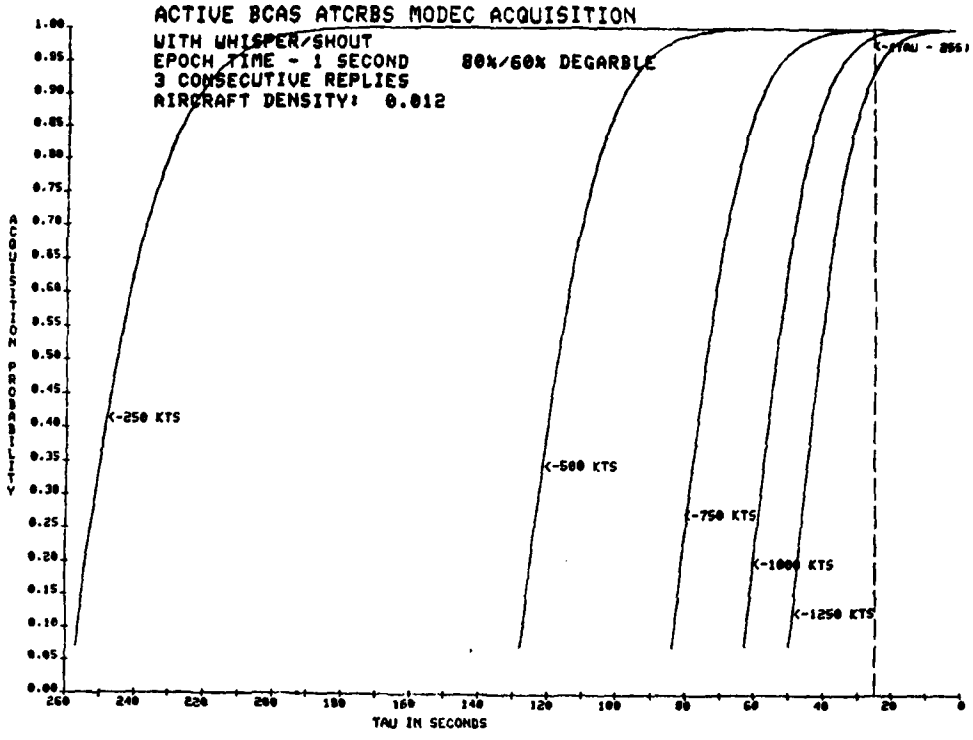


Figure 3
Target Acquisition
in a Density of 0.02



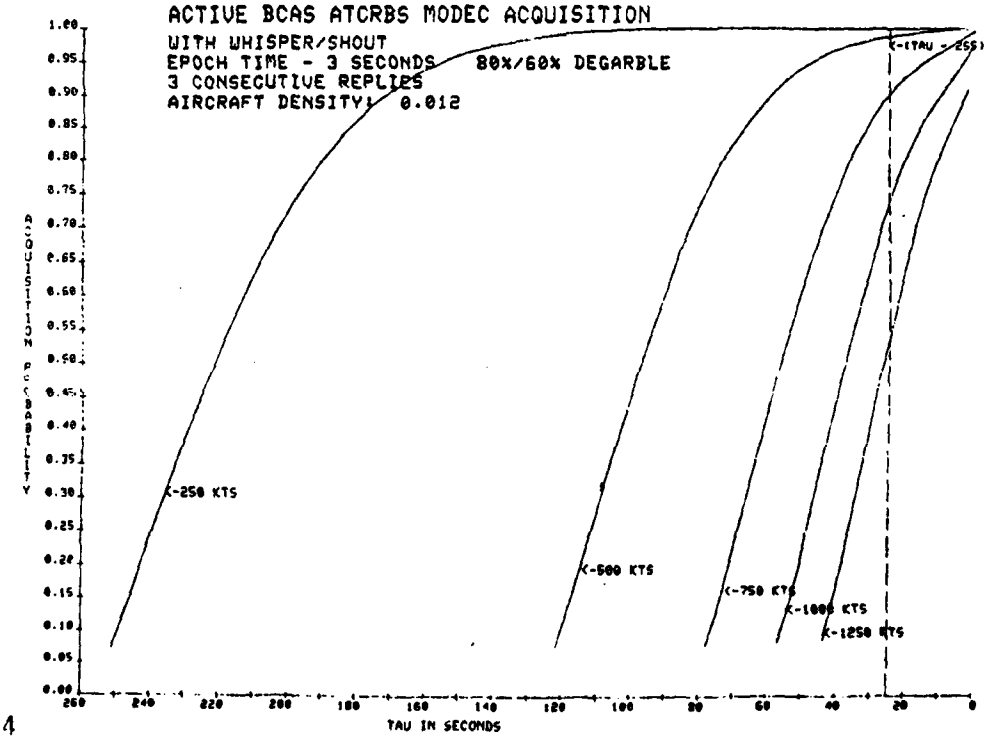


Figure 4
Target Acquisition
in a Density of 0.012

Without a degarble capability in terminal area densities, system performance is diminished significantly. Systems with and without four-level whisper/shout are compared for target acquisition at 25 seconds before collision in Figures 5 and 6. Figure 5 shows the effect of full degarble, deinterleaving, and no degarble with a 1-second update at various aircraft densities. Figure 6 illustrates the same configurations but uses a 3-second epoch length. These graphs represent encounters at closure rates of 500 kts. The least capable of these systems can perform adequately in airspace density of only .004 aircraft/nm^2, and has an epoch length of 3 seconds, no degarble, and no whisper/shout. At a higher density or a closure rate greater than 500 kts, this system cannot perform at a 95% likelihood of success. When deinterleaving is used to degarble a single overlapping reply, the system capability does not achieve more than 90% success in a density of .008 aircraft/nm^2. By using full degarble the performance can reach 93.5% successful acquisition in a density of .012 aircraft/nm^2 when encounters do not exceed the terminal airspace head-on configuration of 500 kts. Referring to Figure 5, the system without whisper/shout, but with a 1-second update rate and full degarble can achieve a 98.9% chance of successful target acquisition up to a density of up to .016 aircraft/nm^2.

Using Figures 5 and 6, the effect of whisper/shout at various densities and a closure rate of 500 kts can be examined. When whisper/shout is added to a 3-second epoch system with full degarble, the performance levels can reach 95% in a density of .02 aircraft/nm^2. The enhancement obtained with whisper/shout is especially noticeable at the higher densities (see Figure 6). The target acquisition capability with full degarble and a 3-second epoch, but without whisper/shout, does not perform as well as the system with whisper/shout and no degarble capability at all in a density of .024 aircraft/nm^2.

The whisper/shout interrogation cycle was tested by comparing a system with five interrogation/suppression levels per epoch with one that

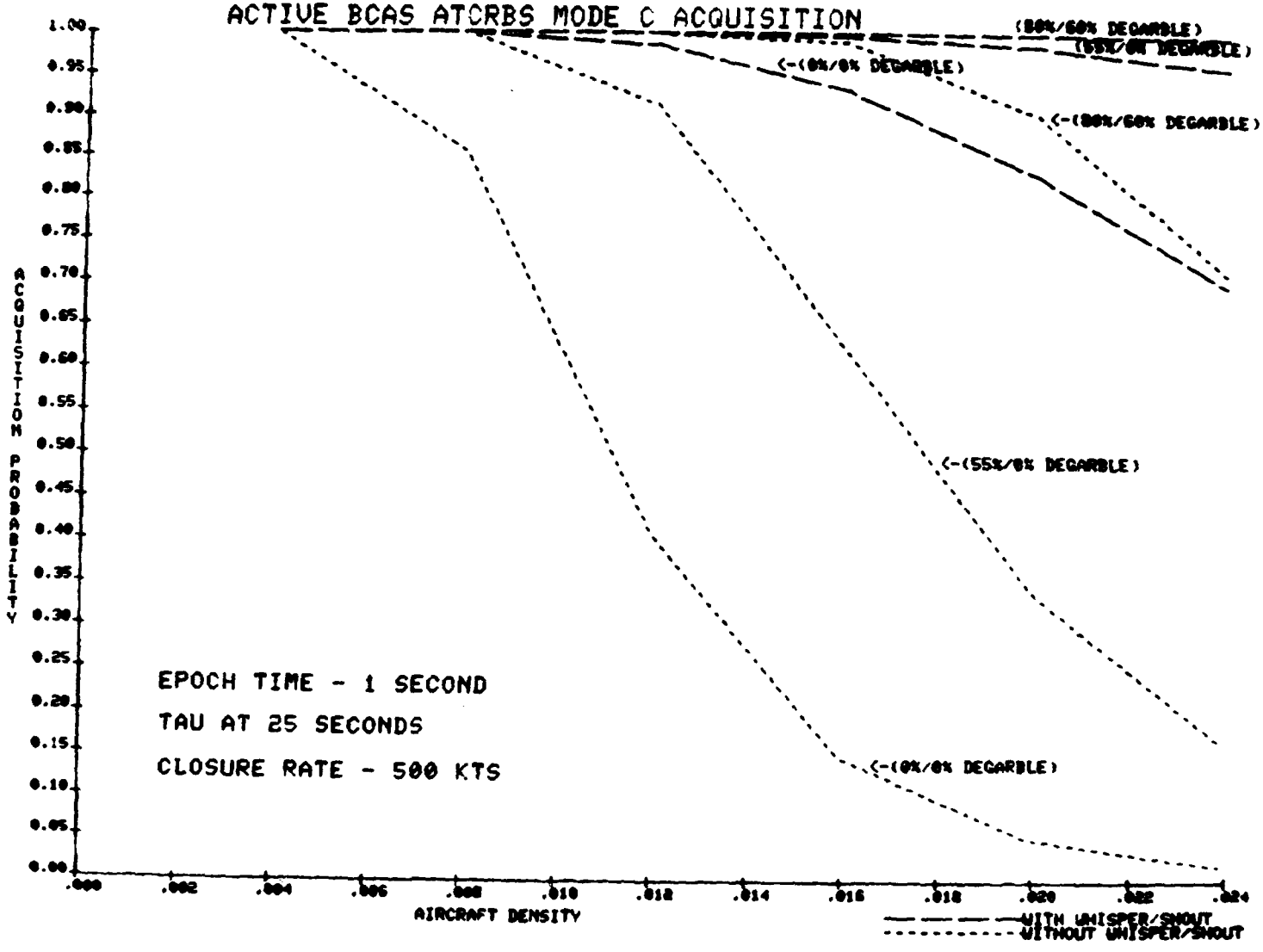


Figure 5 Comparison of Systems with and without Whisper/Shout (1-second)

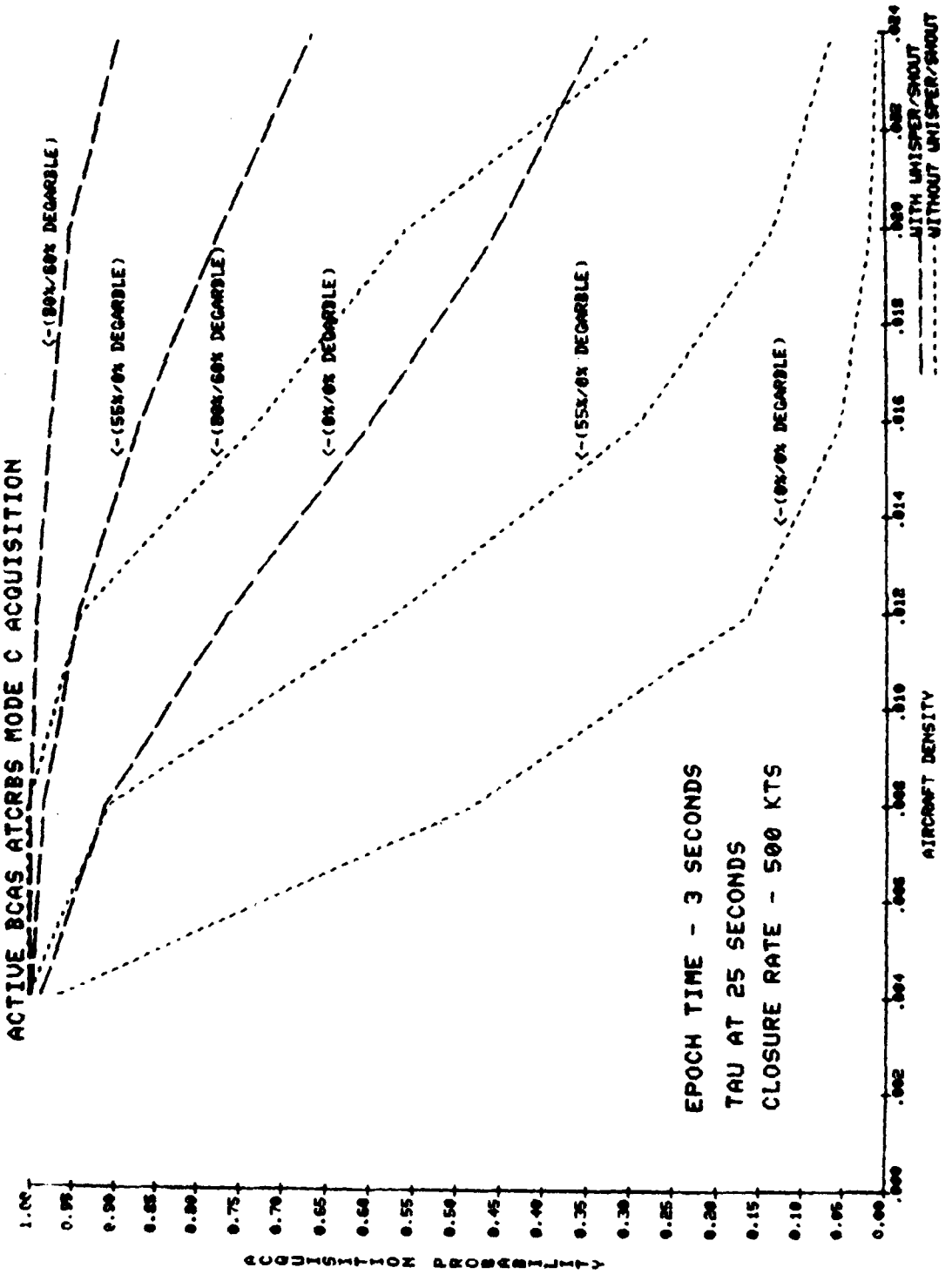
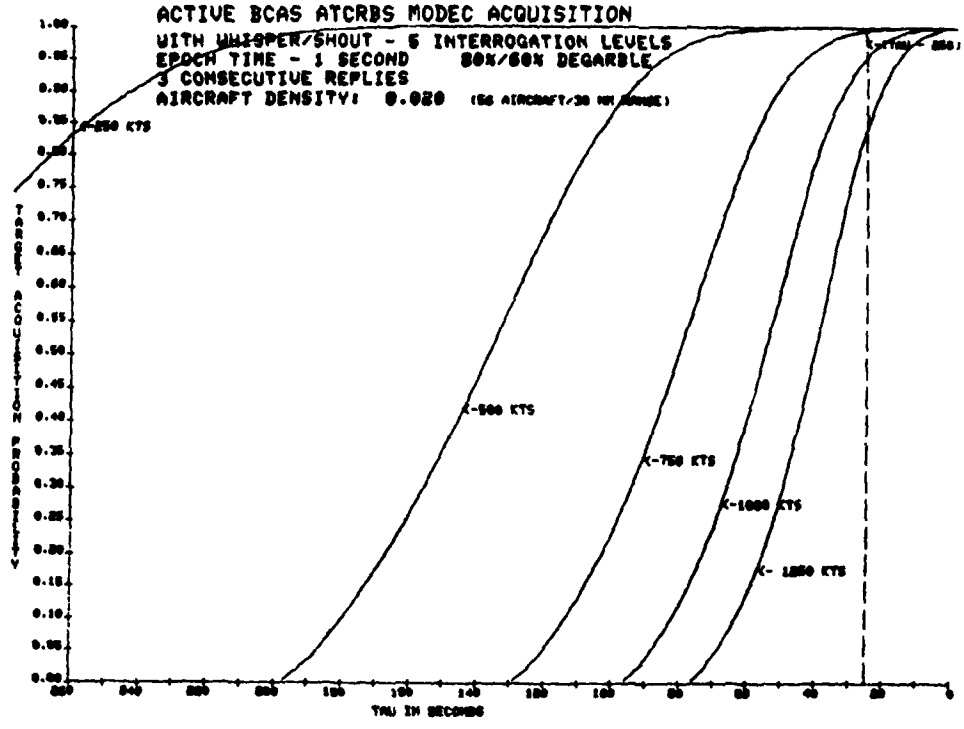


Figure 6 Comparison of Systems with and without Whisper/Shout (3-seconds)

has four levels. The five-level system used a peak power of 62 dbm for its final interrogation. Maximum system range was assumed to be 28 nm with a density of .02 aircraft/nm^2 (56 aircraft in a 30 mile range). The four-level system used a peak power of 57 dbm and the same environment. Results are presented in Figure 7. Because the performance desired is at the 95% level and a fifth level of whisper/shout cannot bring the 1250 kt closure rate encounter higher than 85% acquisition by 25 seconds before collision with the additional interrogation, the whisper/shout design used in any of the simulations had four repetitions.

A low cost general aviation collision avoidance system was tested at a power of 50 dbm with a minimum triggering level of -72 dbm. This design is assumed to have no whisper/shout feature, but the best degarbling capability of 80%/60%. Because of the lower transmitting power, the system was simulated at 10 and 15 mile ranges. The closure rates ranged from 100 to 600 kts to simulate general aviation lower performance encounters ranging from a tail chase to a head-on threat configuration. The results are presented in the two plots of Figure 8.



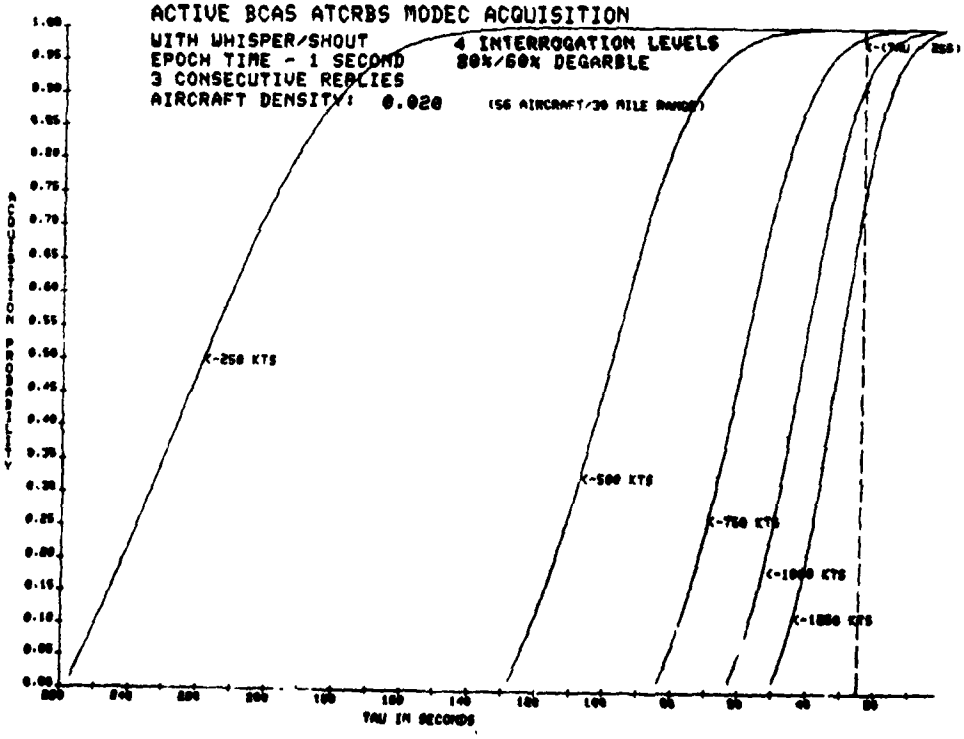
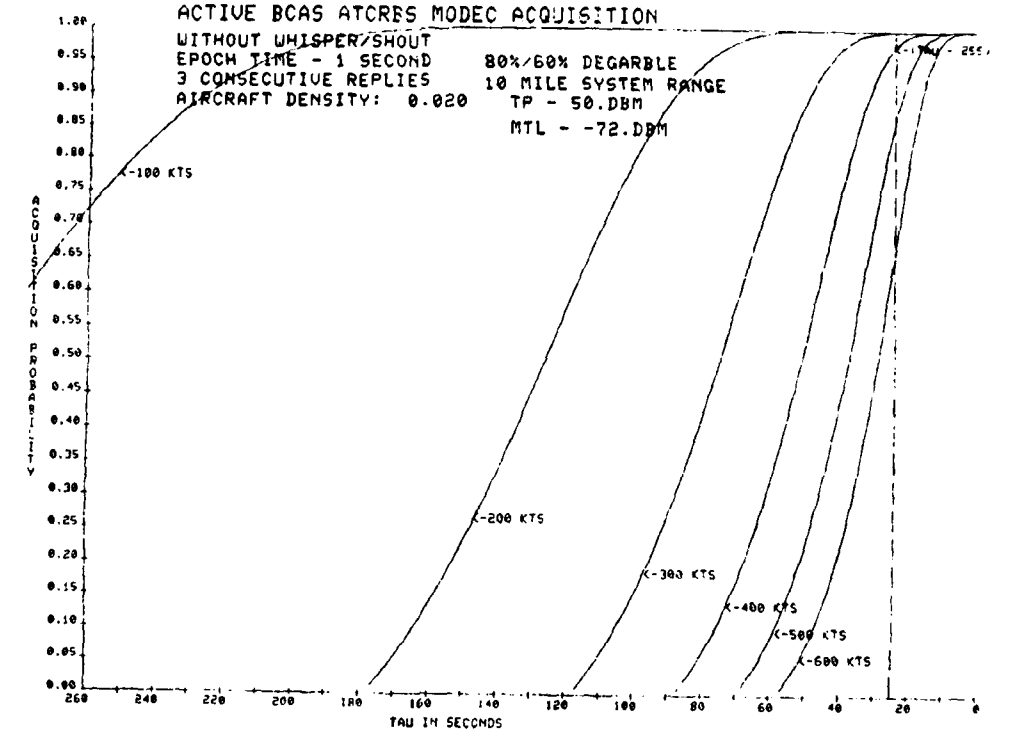


Figure 7 - Whisper/Shout with 4 and 5 Levels



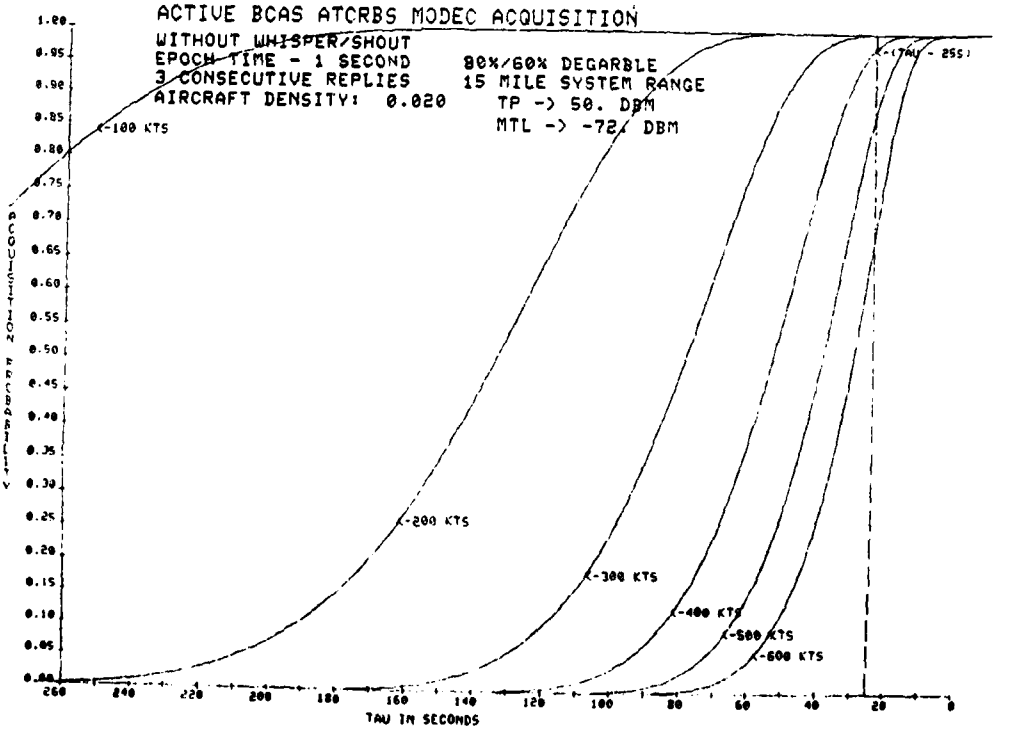


Figure 8 - General Aviation CAS Tested with 10 and 15 nm Ranges

CONCLUSIONS

The requirement for a BCAS system to operate in a density of up to 0.02 aircraft per square nautical mile is stated in the draft U.S. National Aviation Standard for BCAS. The results presented in this study indicate that when the whisper/shout technique is added to any BCAS system design, target detection will be greatly improved. A BCAS which combines whisper/shout, 1-second update rate, and full degarble capability approaches 100% probability of target detection in terminal airspace with a density of 0.02 aircraft/nm^2 when time to collision reaches 25 seconds and closure rate is 500 knots. In en route airspace, this BCAS design will achieve a 97.5% probability of successful acquisition at closure rates of 1250 kts in densities of 0.008 aircraft/nm^2. Thus, it appears that whisper/shout, high update rate and full degarble (80/60) are required to satisfy the draft U.S. National Standard.

The full degarble capability has a significant effect on obtaining clear replies in low to medium density airspace, but in terminal airspace many more than two overlaps can easily occur and the whisper/shout technique will enhance the probabilities for target acquisition by at least 12% in an aircraft density of 0.02.

BCAS epoch length is a critical factor in obtaining acceptable performance from any of the system designs studied in this analysis. Acceptable probabilities of target acquisition in terminal airspace density of 0.02 aircraft per square nautical mile can only be achieved using a design that includes full degarble, whisper/shout, and a 1-second epoch. In the 0.02 aircraft per square nautical mile density, the

1-second epoch will allow the system to acquire a target with almost a 100% reliability at 25 seconds before collision while a 3-second interrogation rate reduces the acquisition reliability to below 95%. The probability of track acquisition represents the likelihood of initiating track; at this time the track has not yet been determined to be a threat, and coordination of maneuvers could not have been done. The following tables show the maximum density for which each system can achieve a 99.5% criterion of track acquisition in terminal area encounters 25 seconds before collision. This high degree of reliability of track initiation is critical to acceptable system performance.

		Full degarble	Deinterleaving	No degarble
1-second epoch	Whisper/ Shout	.024	.016	.008
	No Whisper/ Shout	.012	.008	.004

		Full degarble	Deinterleaving	No degarble
3-second epoch	Whisper/ Shout	.008	.004	less than .004
	No Whisper/ Shout	.008	.004	less than .004

With full degarble, and with or without whisper/shout, a 3-second epoch system's capability is limited to a density of .008 aircraft per square nautical mile. If the 3-second system is operated with less than full degarble and with or without whisper/shout, it can handle only .004 aircraft per square nautical mile. By using a 1 second epoch, a system design with less than full degarble but including

whisper/shout can provide reliable performance in densities of up to 0.016 aircraft per square nautical mile.

It is obvious from the data presented that whisper/shout enhances BCAS acquisition in dense airspace, and that full degarble combined with the whisper/shout technique and 1-second epochs provides the best system for terminal area operation. In fact, without all of these features it appears to be impossible to satisfy the requirements of the draft U.S. National Standard for BCAS.

REFERENCES

1. Shuchman, L.; "An Active Beacon-Based Collision Avoidance System Concept (BCAS)," MITRE Corporation Project Report, MTR-7036. FAA Report, FAA-EM-75-7, October 75.

2. Koenke, Dr. Edmund J.; "Active BCAS Performance in a Garble Environment," FAA Report, FAA-EM-80-1, January 1980.

3. Harman, William; "Effects of RF Power Deviation on BCAS Link Reliability," Lincoln Laboratory Project Report, ATC-76, June 1977.

4. Lipschutz, Seymour; Probability. New York: McGraw Hill Company, Inc., 1965.

Appendix 1

Simulation Program Listing

```
C----- ----- ----- ----- ----- -----
C     TARGET ACQUISITION PROBABILITY
C     USING WHISPER SHOUT TECHNIQUE WITH FOUR
C     INTERROGATION POWER LEVELS AND THREE
C     SUPPRESSION LEVELS
C     DEGARBLE PROBABILITIES FOR 2 AIRCRAFT
C
C        SANDY BOCZENOWSKI -- AEM-200
C        FINAL VERSION   APR 29, 1980
C----- ----- ----- ----- ----- -----
         INTEGER*2  EPOCH,TAQ,EPS
         LOGICAL*1 NAM(14)
         INTEGER*2  CODE1,CODE2,PRIN11
         INTEGER*4 NUMBER
         REAL*4 P(600),MTL,R(600),SR(600),RES(600)
         DATA NAM(9)/'.'/,NAM(10)/'D'/,NAM(11)/'A'/,NAM(12)/'T'/,
     +   NAM(13)/';'/,NAM(14)/'1'/
C
C----- OPEN A DATA FILE TO STORE THE RESULTING PROBABILITIES
C
         WRITE(1,990)              !ASK USER FOR FILE NAME
            READ(1,991)(NAM(K),K=1,8)
         CALL ASSIGN(2,NAM,14)
         DEFINE FILE 2 (1000,4,U,NREC)
C
         WRITE(1,100)
         CALL SETUP2 (ETIM,N,G1,G2,SRNG,IWS)
C
         NREC =1
            WRITE(1,150)N
C
C           -- CONTROL RELATIVE SPEED --
           DO 20 IS = 250,1250,250
            S = FLOAT(IS)/3600.
            T0 = SRNG/S
            MXEPS = INT(T0/ETIM+ .5 )              !NO. OF EPOCHS
```

```
C
      IF(IWS.EQ.0)CALL PROB(T0,MXEPS,ETIM,G1,G2,N,S,P)
      IF(IWS.EQ.1)CALL PROBWS(T0,MXEPS,ETIM,G1,G2,N,S,P)
C
C----- STEP THROUGH NO. OF EPOCHS FROM  MIN NO. FOR SUCCESS TO TIME = 0
C
      DO 12 EPS = 3,MXEPS
         R(EPS) = P(EPS-2) * P(EPS-1) * P(EPS)
12    CONTINUE
      DO 13 EPS = 4,MXEPS
         R(EPS) = R(EPS) * (1. - P(EPS-3))
13    CONTINUE
      SR(2) = 0.
C
      DO 17 EPS = 3,MXEPS
      IF ( EPS .LT. 7) GO TO 216
          K = EPS -4
          DO 15 I = 3,K
              SR(I) = SR(I-1) + RES(I)
15        CONTINUE
16        RES(EPS) = R(EPS) * (1. - SR(K))
        GO TO 17
216     RES(EPS) = R(EPS)
17    CONTINUE
C
      PSUM = 0.0
C     WRITE(1,159)IS
      DO 19 EPS = 3,MXEPS
      REPS = FLOAT(EPS)
      PSUM = PSUM + RES(EPS)
C     WRITE(1,160)EPS,R(EPS),SR(EPS-4),RES(EPS),PSUM
      WRITE(2'NREC)REPS,PSUM
C
19    CONTINUE
20    CONTINUE                    !RELATIVE SPEED LOOP
C
```

```
      CALL CLOSE (2)
      STOP
100   FORMAT(/' -- TARGET ACQUISITION SIMULATION --'/,
     +' N CONSECUTIVE REPLIES FOR SUCCESS '/,
     +'   WHISPER/ SHOUT  PROBABILITIES ')
150   FORMAT(3X,'NO. OF AC',I4,4X,'VEL.',5X,'PROB.')
155   FORMAT(' $,DISP1,DISP2 --> ',3(2X,I4))
159   FORMAT(/'    CLOSURE RATE - ',I6/,6X,'EPOCH',5X,' R ',8X,' S ',
     +  7X,' RES ',7X,'  SUM')
160   FORMAT(5X,I3,4(3X,F9.5))
990   FORMAT('$   FILE NAME FOR DATA STORAGE?(UP TO 8 CHARS)-> ')
991   FORMAT(8A1)
      END
C
C
C-----------------------------------------------------------------
C
C     SUBROUTINE TO GENERATE PROBABILITY OF MODE A COORDINATION
C     FOR UP TO 600 CONSECUTIVE EPOCHS
C
C     WRITTEN BY S. BOCZENOWSKI       12/17/79
C-----------------------------------------------------------------
      SUBROUTINE PROBWS(T0,LIMIT,ETIM,G1,G2,N,S,P)
      REAL*4 PD(4),P(600),NC,PL(4),PS(4),PK(4)
      REAL*4 INTP(4),SUPP(4),FSPL,CL,MTL,LR(4),LM,PI
C
C----- POWER LEVELS FOR WHISPER/SHOUT CALCULATIONS
C
      DATA INTP/39.,45.,51.,57./
      DATA SUPP/0.,37.,43.,49./
C
      DR = 20.3 / 6.08 *.5              ! 1/2 MESSAGE LENGTH
      R  = 20.                  !RADIUS OF SURVEILLANCE
      PI = 3.14159265
C
      TI = T0                   !INITIAL TAU
```

```
                                        *
          NC = FLOAT (N -1)          !DO NOT COUNT TARGET AIRCRAFT
          CL = 6.0
          MTL = -77.0
C
C------ COMPUTE PROBABILITY FOR EACH OF THE EPOCHS
C
          DO 220  J = 1,LIMIT
            FSPL = 20.0 * ALOG10(4.0*PI*S*TI *6076.115 / 0.903)
            PE = (4.*S*TI*DR)/(R**2)
C
C------ COMPUTE EACH WHISPER/SHOUT LEVEL
C
            DO 150 K = 1,4                    !FOR EACH LEVEL
C
C------ INTERROGATION RELIABILITY(USING DIVERSITY TO SINGLE VALUES)
C
            LM = INTP(K) - FSPL -CL -MTL             !LINK MARGIN
            PL(K)=.4406575 +0.0765315*LM+.0005927*(LM**2) -
                  .00026524*(LM**3)
            IF(PL(K) .GT. 1.0) PL(K) = 1.0
              IF(LM .LT. -11.0) PL(K) = 0.0
              IF(LM .GT. 13.0) PL(K) = 1.0
C
C------ SUPPRESSION RELIABILITY
C
            IF(K .EQ.1) GO TO 95
            SM = SUPP(K) - FSPL-CL -MTL
            PS(K)=.4406575 +0.0765315*SM+.0005927*(SM**2) -
                  .00026524*(SM**3)
          IF(PS(K) .LT. 0.0) GO TO 95
             PS(K) = SQRT(PS(K))
          IF(PS(K) .GT. 1.0) PS(K) = 1.0          !LIMIT TO ONE
          IF(SM .LT. -11.0) PS(K) = 0.0
          IF(SM .GT. 13.0) PS(K) = 1.0
          GO TO 101
95        PS(K) = 0.0
```

```
101     CONTINUE
C101    WRITE(1,333)K,LM,PL(K),SM,PS(K)
333     FORMAT('  K = ',I3,'  INTERR.-->',2F10.4,' SUPPR.-->  ',2F10.4)
          PK(K) = PE * PL(K) * (1.0 - PS(K))
          PD(K) = PL(K) * (1.0-PS(K)) * ((1.0-PK(K))**NC +
     ,                    NC * PK(K) * (1.0-PK(K))**(NC-1.) * G1 +
     ,             NC * (NC-1.)/2.*PK(K)**2 * (1.0 - PK(K))**(NC-2.)*G2)
C         WRITE(1,900)K,TI,PD(K)
900       FORMAT(' W/S LEVEL ',I4,' TAU ',F9.0,' PROB. ',F9.4)
150       CONTINUE
C
C----- PROBABILITY AFTER ALL WHISPER SHOUT ATTEMPTS
C
        P(J) = 1.0 - ( (1.0 - PD(1))*(1.0 - PD(2))*(1.0 - PD(3))
     +                 *(1.0 - PD(4)) )
          TI = T0 - (ETIM * J)
C         WRITE(1,904)J,TI,P(J)
904     FORMAT(' EPOCH ',I5,'  TAU ',F5.0,' PROBABILITY ',F9.5)
220     CONTINUE
         RETURN
100     FORMAT('  ---ROUTINE PROB---')
998     FORMAT(X,A1)
          END
C-----------------------------------------------------------------
C
C        REQUEST INPUT FOR VARIABLE CONDITIONS IN SIMULATION
C       EPOCH DURATION, MINIMUM NO. OF REPLIES TO DECLARE A SUCCESS,
C       DEGARBLE PROBABILITIES FOR TWO OTHER REPLIES, AND A SYSTEM
C       RANGE VALUE USED TO DETERMINE TAU AND NO. OF EPOCHS
C
C       WRITTEN BY S.BOCZENOWSKI                    12/17/79
C
C-----------------------------------------------------------------
        SUBROUTINE SETUP2 (ETIM,N,G1,G2,SR,IWS)
        INTEGER*2 EPS,JUNK(5)
        REAL*4 MTL
```

```
C
      WRITE(1,100)
C
      WRITE(1,904)              !SYSTEM RANGE IN MILES
          READ(1,903)SR
      WRITE(1,917)              !TIME PER EPOCH
          READ(1,901)ITIM
              ETIM = FLOAT(ITIM)
C     WRITE(1,918)                        !MINIMUM REPLIES FOR SUCCESS
C         READ(1,901)REPMIN
75    WRITE(1,905)     !AIRCRAFT DENSITY
          READ(1,901)N
      IF(N .GT.5.OR.N.LT.100) GO TO 80
      WRITE(1,936)
      GO TO 75
80    WRITE(1,907)              !USE WHISPER SHOUT TECHNIQUE?
          READ(1,901)IWS
      WRITE(1,920)              !PROB OF DEGARBLE
          READ(1,903)G1
      IF(G1.EQ..8)IDG=1
      IF(G1.EQ..55)IDG=2
      IF(G1.EQ.0)IDG=3
      WRITE(1,922)              !DEGARBLE OF 2 OVERLAPS
          READ(1,903)G2
C     WRITE(1,924)              !TRANSMIT POWER
C         READ(1,903)TP
C     WRITE(1,926)              !MINIMUM TRIGGERING LEVEL
C          READ(1,903)MTL
      WRITE(2'583)IWS,ITIM,N,IDG
      RETURN
C-------------------------------------------------------------------------
C     CONSOLE I/O FORMATS
C-------------------------------------------------------------------------
100   FORMAT('  ---ROUTINE SETUP2---')
901   FORMAT(I5)
903   FORMAT(F12.4)
```

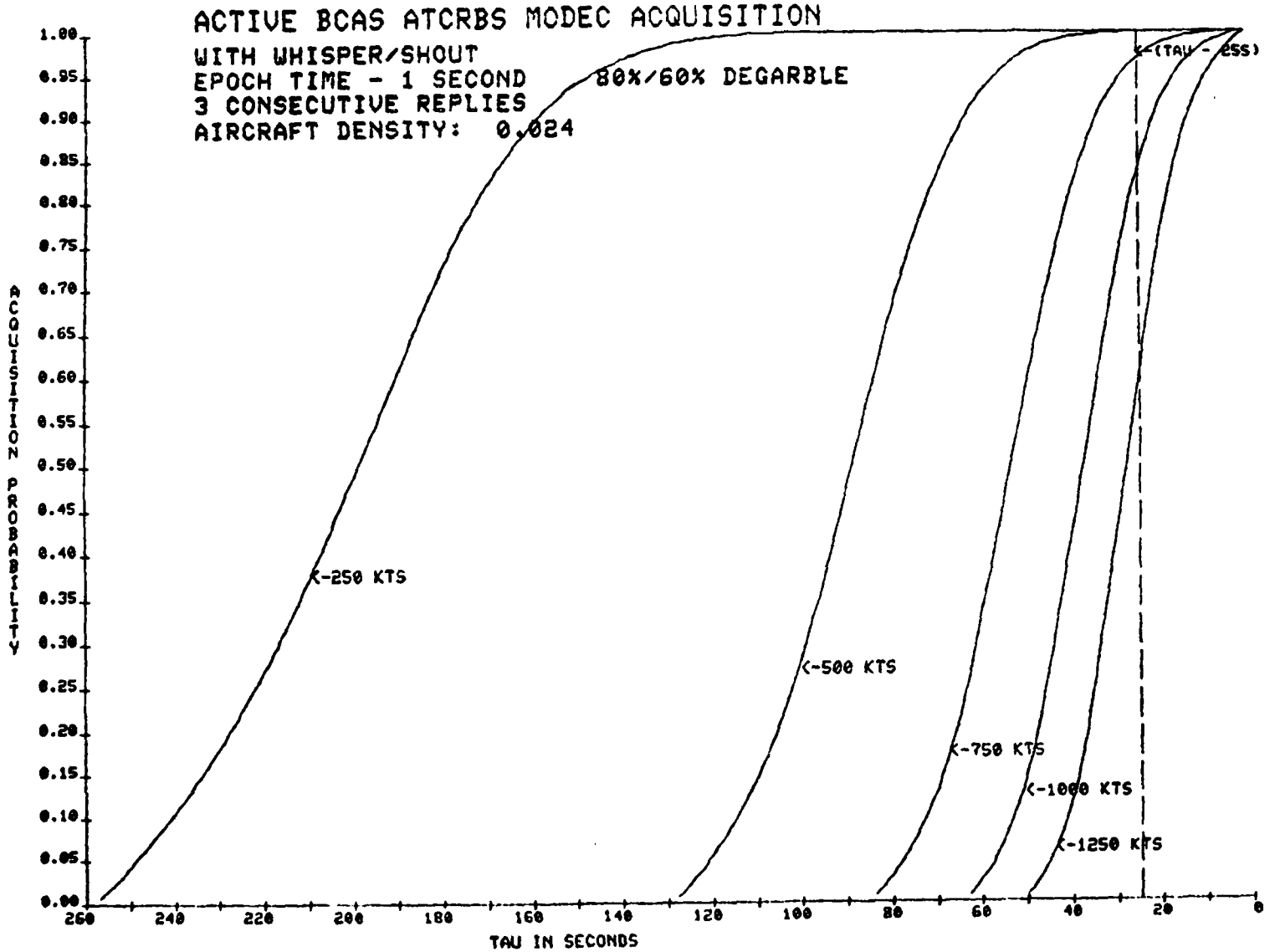
```
904     FORMAT('$       ENTER THE SYSTEM RANGE IN MILES(R)--> ')
905     FORMAT('$       ENTER THE AIRCRAFT DENSITY(5-100)--> ')
906     FORMAT('$EPOCH INTERVAL IN SECONDS (R)--> ')
907     FORMAT('$       WHISPER/SHOUT(1-YES,0-NO)--> ')
908     FORMAT('$INITIAL TIME (TAU IN SECONDS:R)--> ')
916     FORMAT('$       NO. OF EPOCHS  (I) --> ')
917     FORMAT('$       EPOCH TIME IN SECONDS (I)--> ')
918     FORMAT('$     NO. OF REPLIES FOR TARGET ACQUISITION (I) --> ')
920     FORMAT('$      DEGARBLE PROBABILITY 1ST OVERLAP (R)--> ')
922     FORMAT('$      DEGARBLE PROBABILITY 2ND OVERLAP (R) --> ')
924     FORMAT('$      TRANSMITTING POWER (R) --> ')
926     FORMAT('$       MINIMUM TRIGGERING LEVEL (R) --> ')
936     FORMAT('  AIRCRAFT DENSITY RANGE IS 5-100')
988     FORMAT('$PAGE OUTPUT(1) OR SCROLLING(2)--> ')
998     FORMAT(X,A1)
        END
*
```

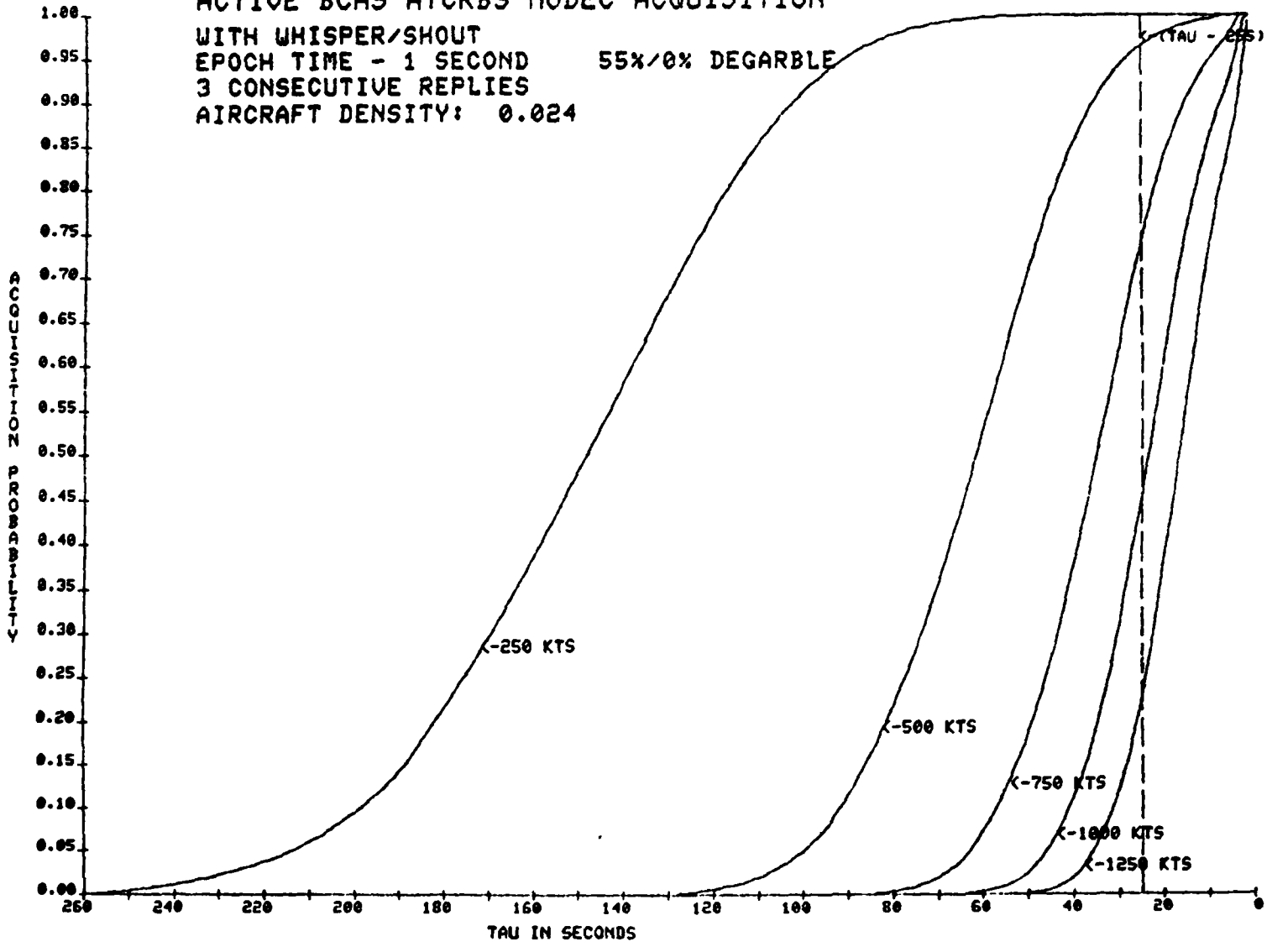
```
                                                  *
      SUBROUTINE PROB (T0,LIMIT,ETIM,G1,G2,N,S,P)
      REAL*4 P(300),PL,NC
      REAL*4 TP,FSPL,CL,MTL,LR,LM,PI
C
C----- CONSTANT VALUE 1/2 MESSAGE LENGTH
C
      DR = 20.3 / 6.08 *.5
      R  = 20.                    !RADIUS OF SURVEILLANCE
C
      TI = T0                     !INITIAL TAU
      NC = FLOAT (N -1)           !DO NOT COUNT TARGET AIRCRAFT
C
C----- COMPUTE PROBABILITY FOR EACH OF THE EPOCHS
C
      DO 111  K = 1,LIMIT
      PI = 3.14159265
      FSPL = 20.0 * ALOG10(4.0*PI*S*TI *6076.115 / 0.903)
      CL =6.0
      TP = 57.
      MTL = -77.
      LM = TP - FSPL - CL - MTL
C
C----- DIVERSITY / SINGLE (LINCOLN VALUES)
      LR=.4406575 +0.0765315*LM + .0005927*(LM**2) -.00026524*(LM**3)
      IF(LR .GT. 1.0) LR = 1.0          !LIMIT TO ONE
      IF(LM .LT. -11.0) LR = 0.0
      IF(LM .GT.13.0) LR = 1.0
C     WRITE(1,333)LR,LM,TP,FSPL,CL,MTL
333   FORMAT('  LR -->',6F10.4)
        PL = ((4.*S*DR*TI)/R**2) *LR
        P(K) = (1. - PL)**NC
        P(K) = (P(K) + NC*PL*(1. - PL)**(NC-1.)*G1)
       P(K)=P(K)+(G2/2.)*NC*(NC-1)*(PL**2)*((1-PL)**(NC-2))

      P(K) = P(K) * LR
C       WRITE(1,900)K,TI,P(K)
```

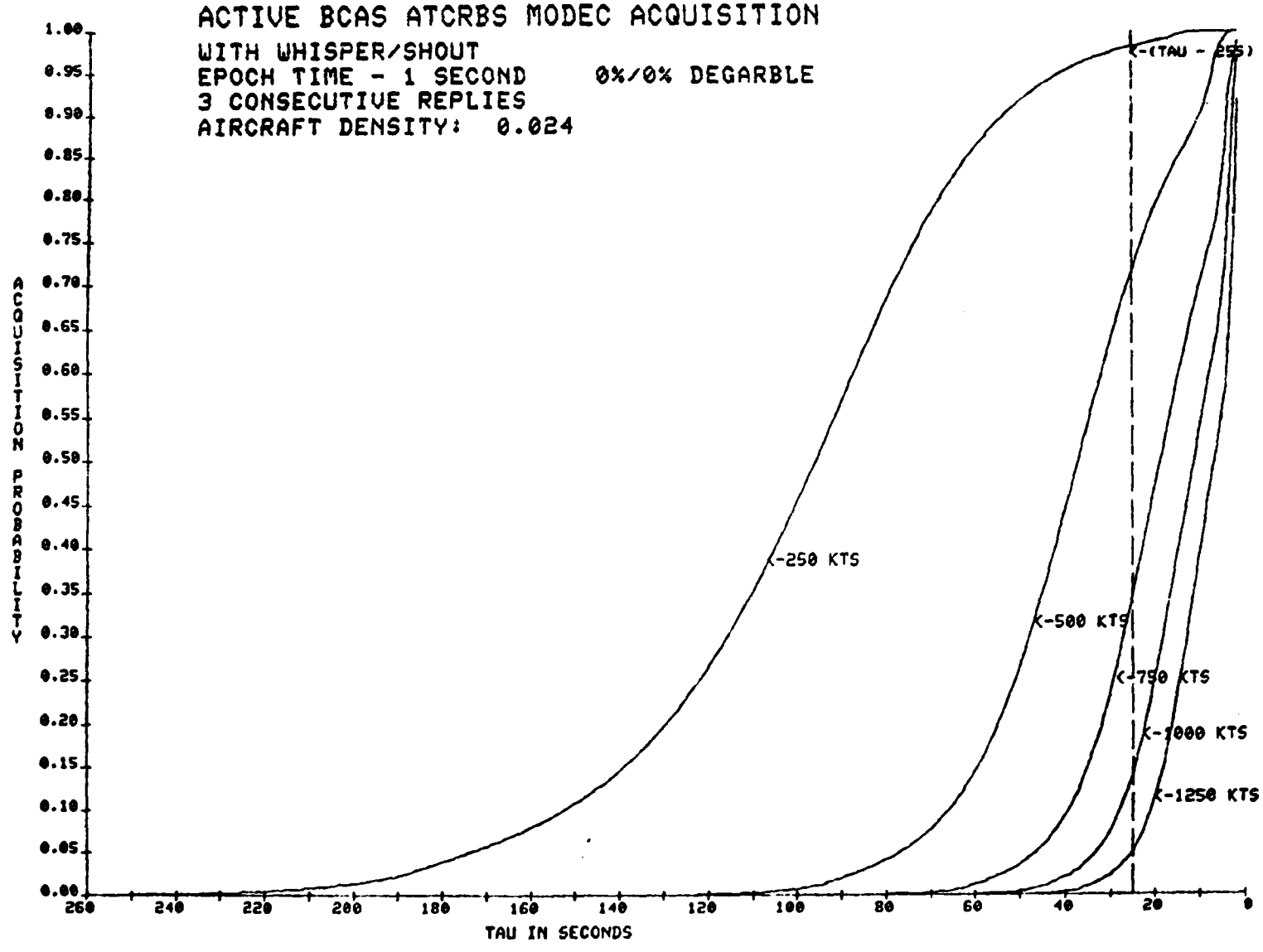
```
900         FORMAT(' EPOCH ',I4,' TAU ',F9.0,' PROB. ',F9.4)
            TI = T0 - (ETIM * K)
111       CONTINUE
           RETURN
100       FORMAT('  ---ROUTINE PROB---')
998       FORMAT(X,A1)
          END
*
```

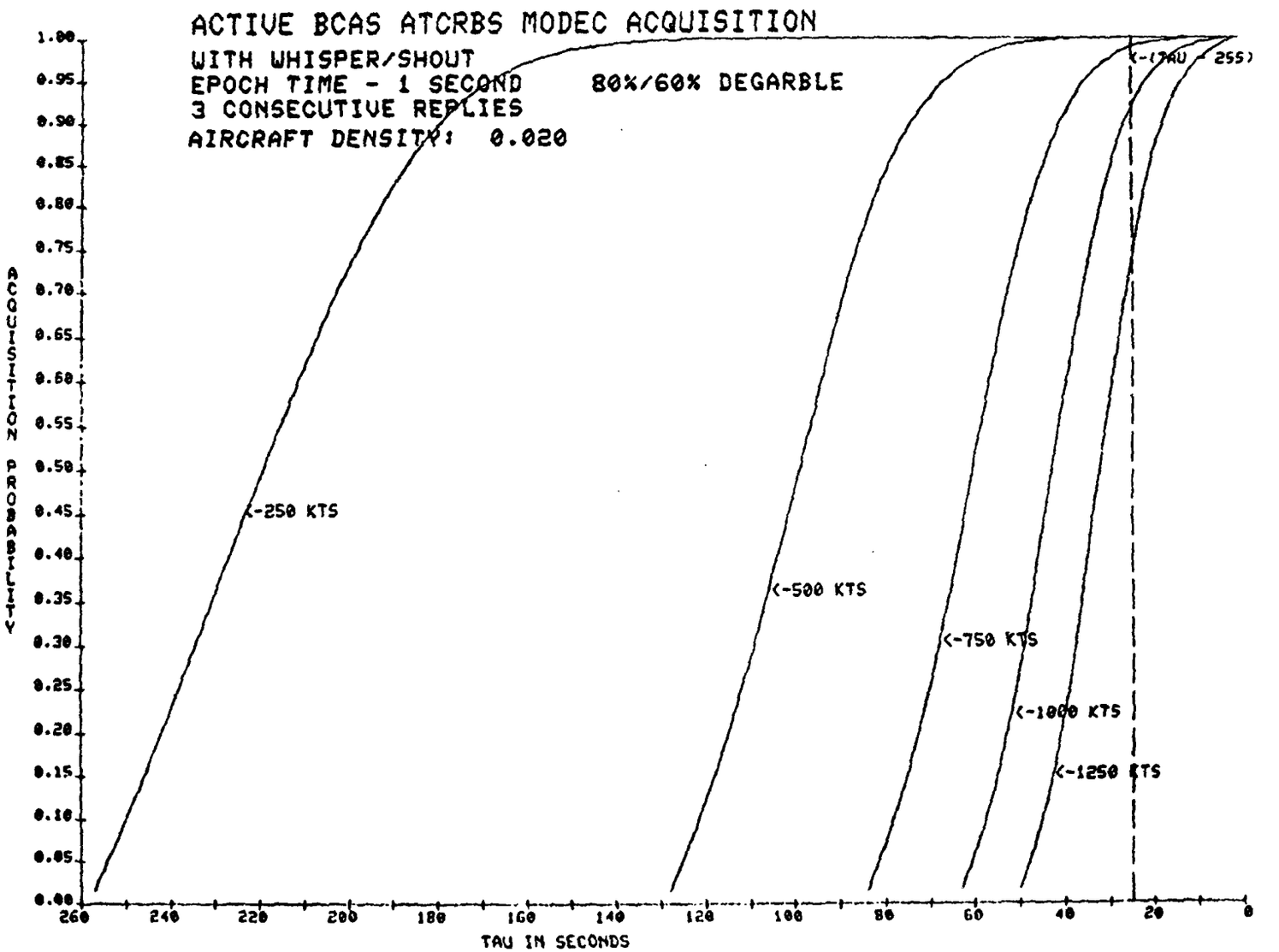
Appendix 2

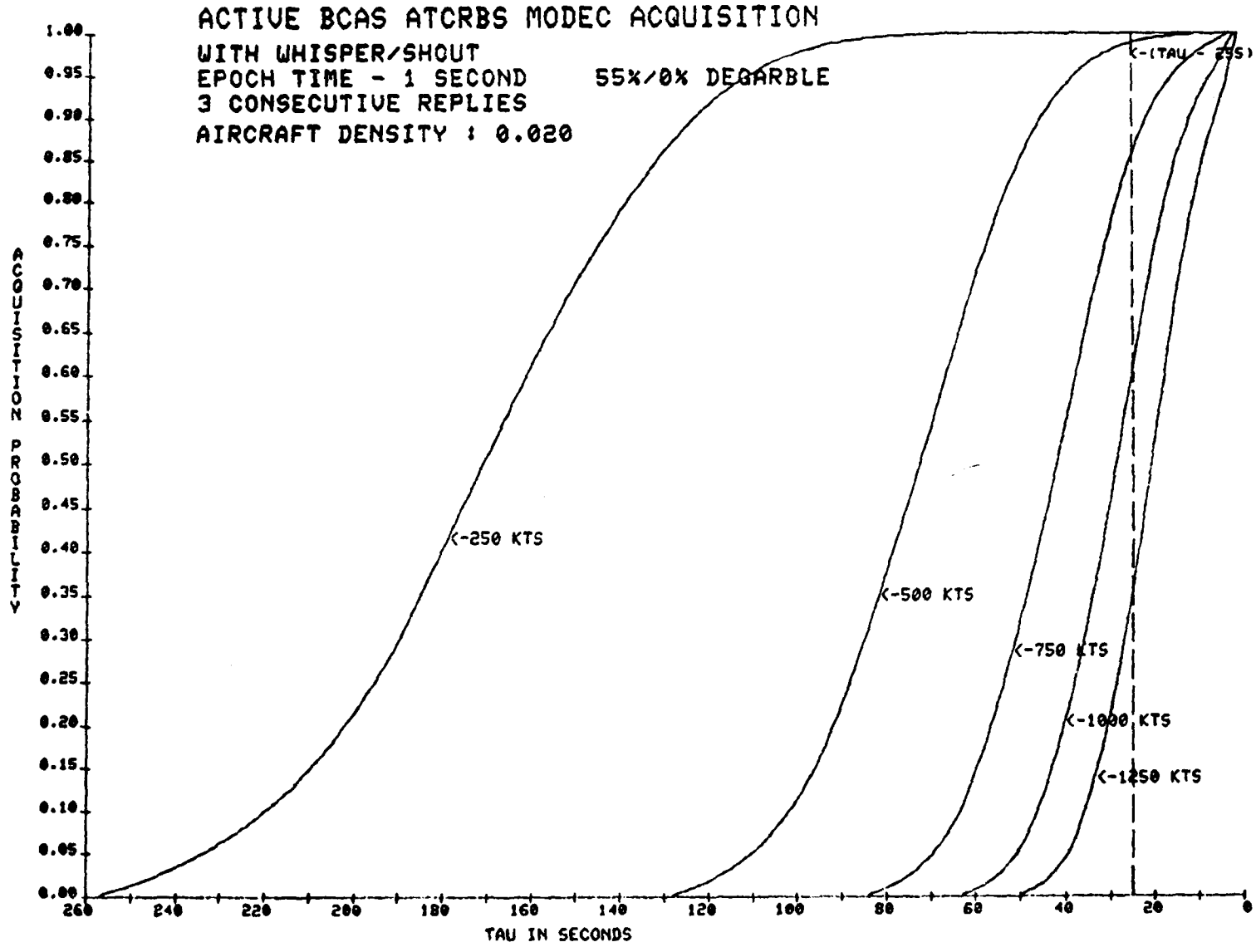
Threat Acquisition Plots

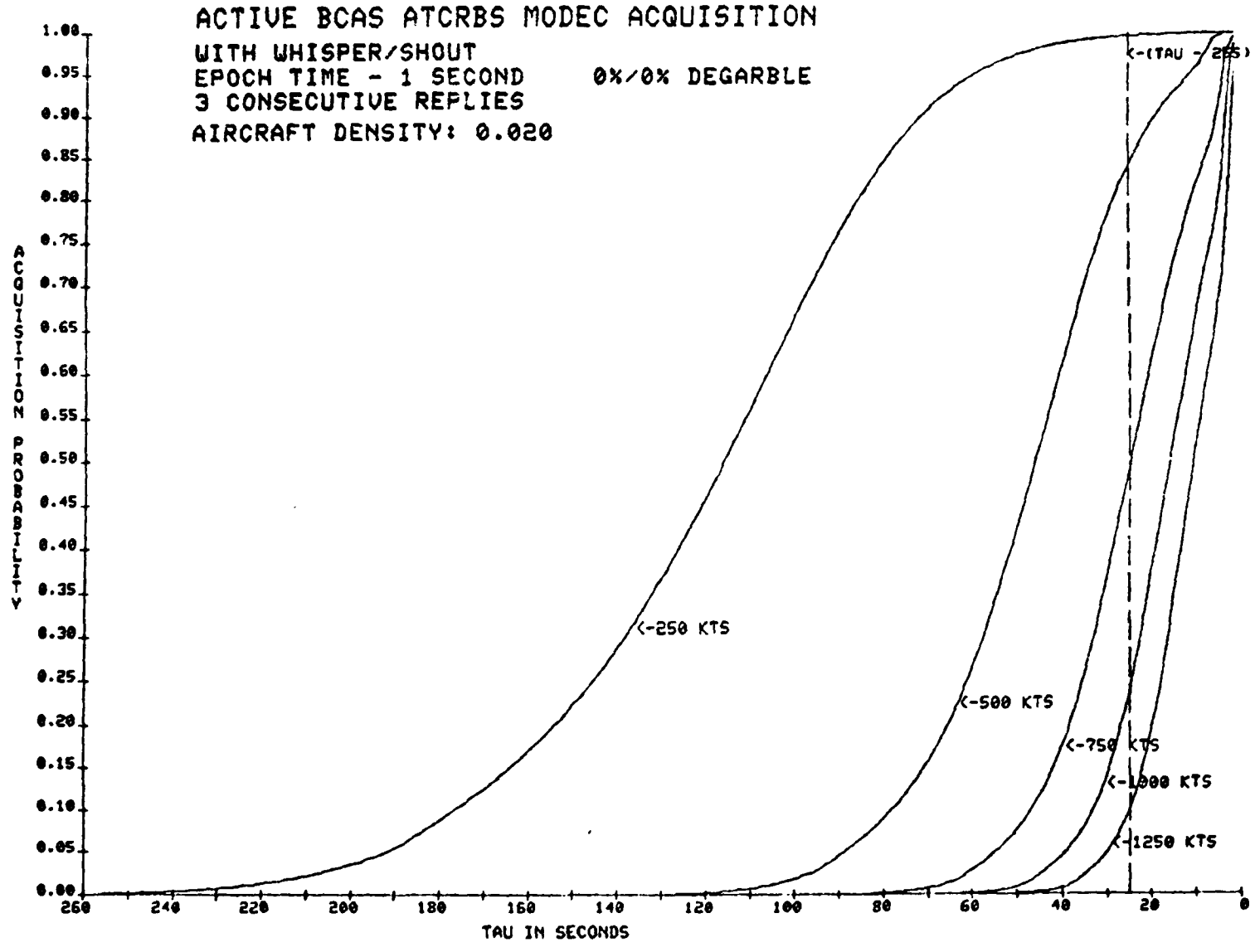

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
80%/60% DEGARBLE
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU - ESS)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS

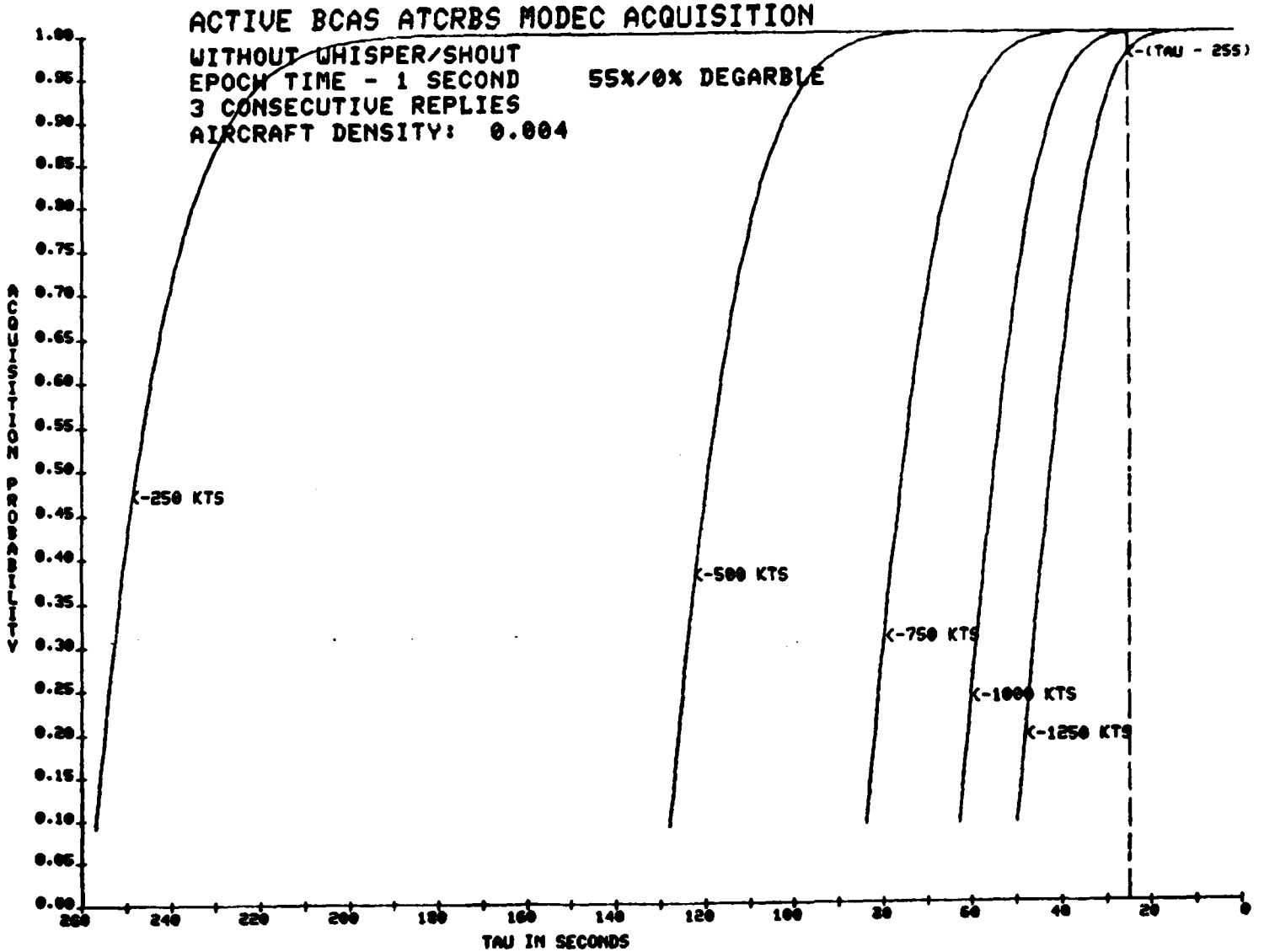

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

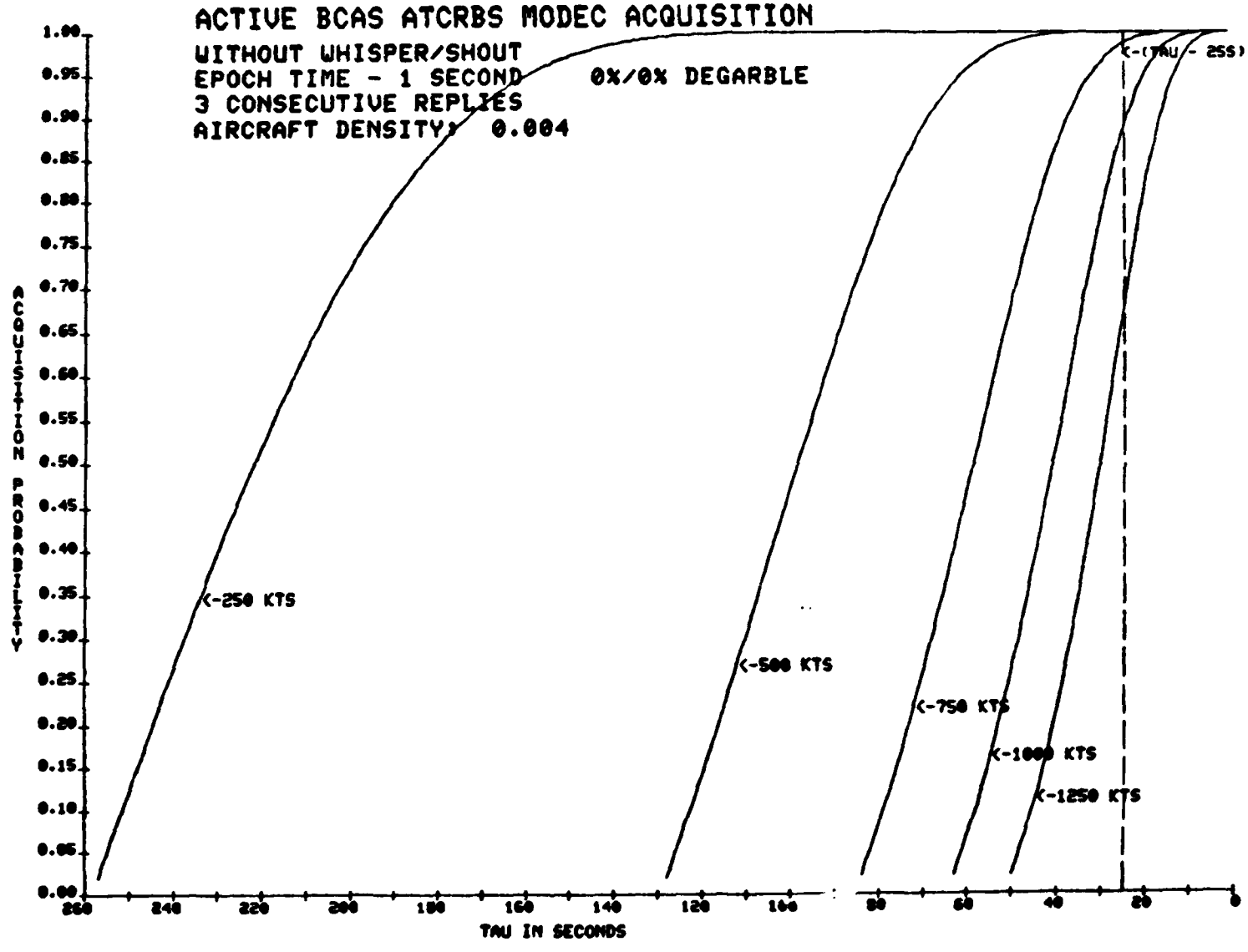

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS

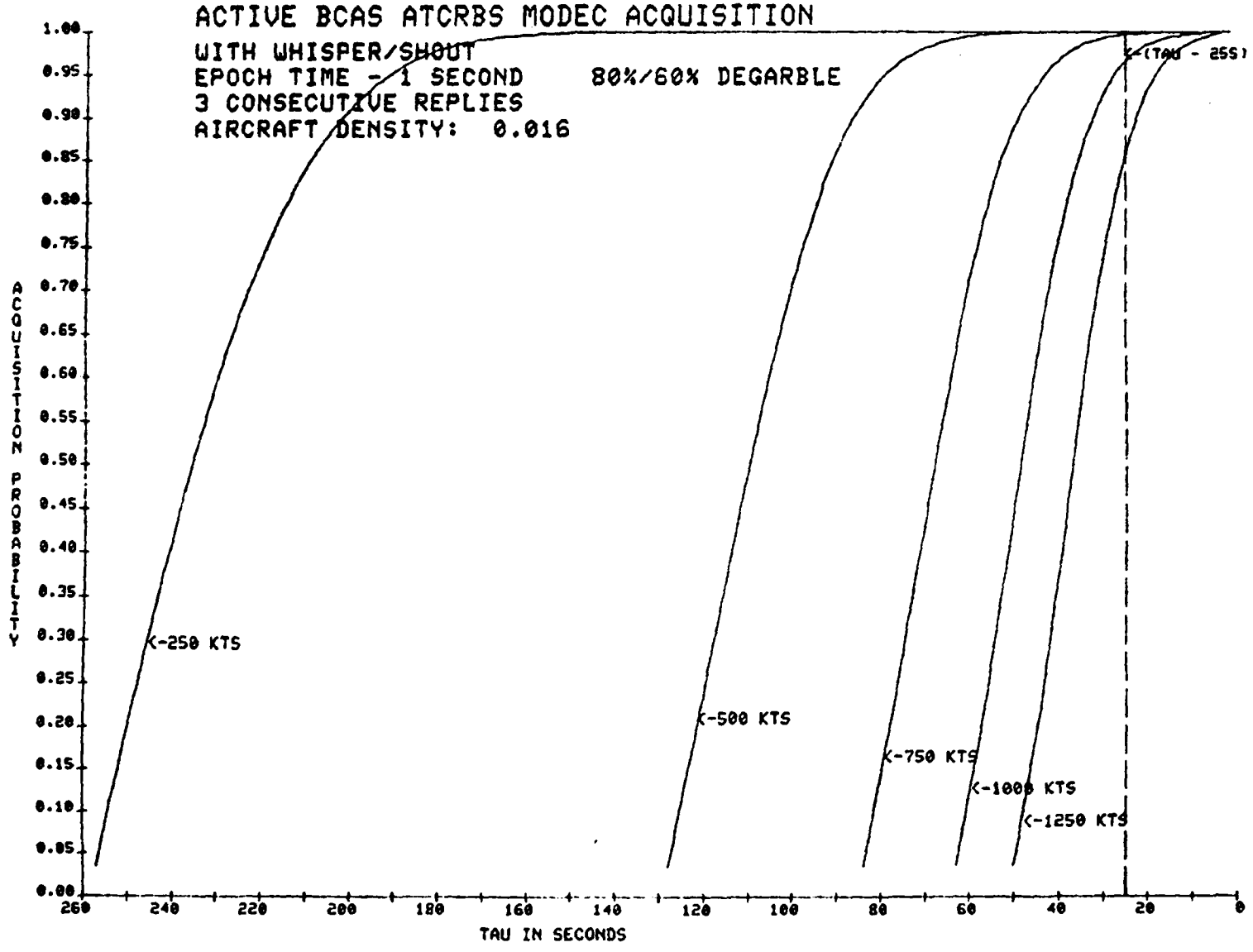

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU = 255)

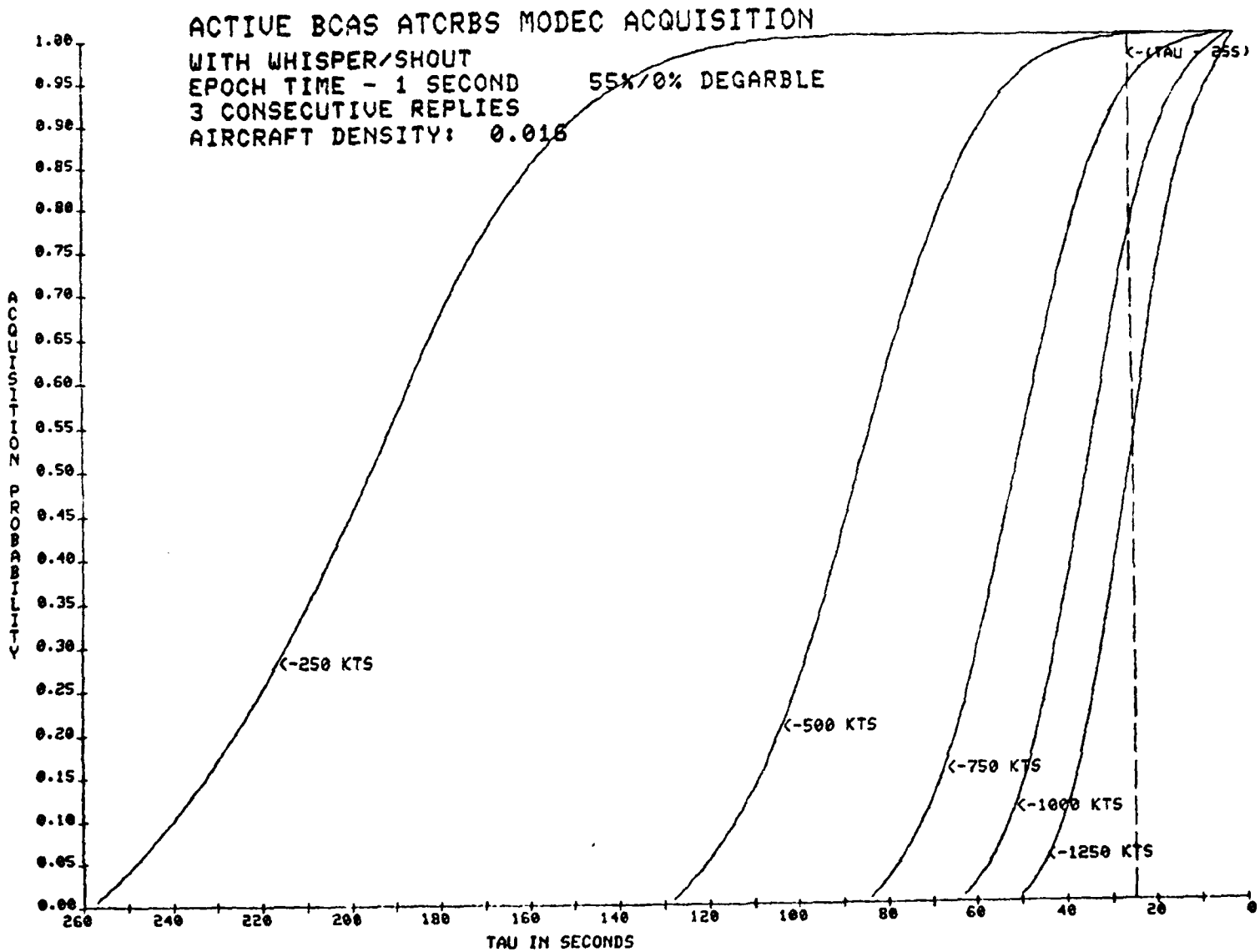

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY : 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU = 23S)

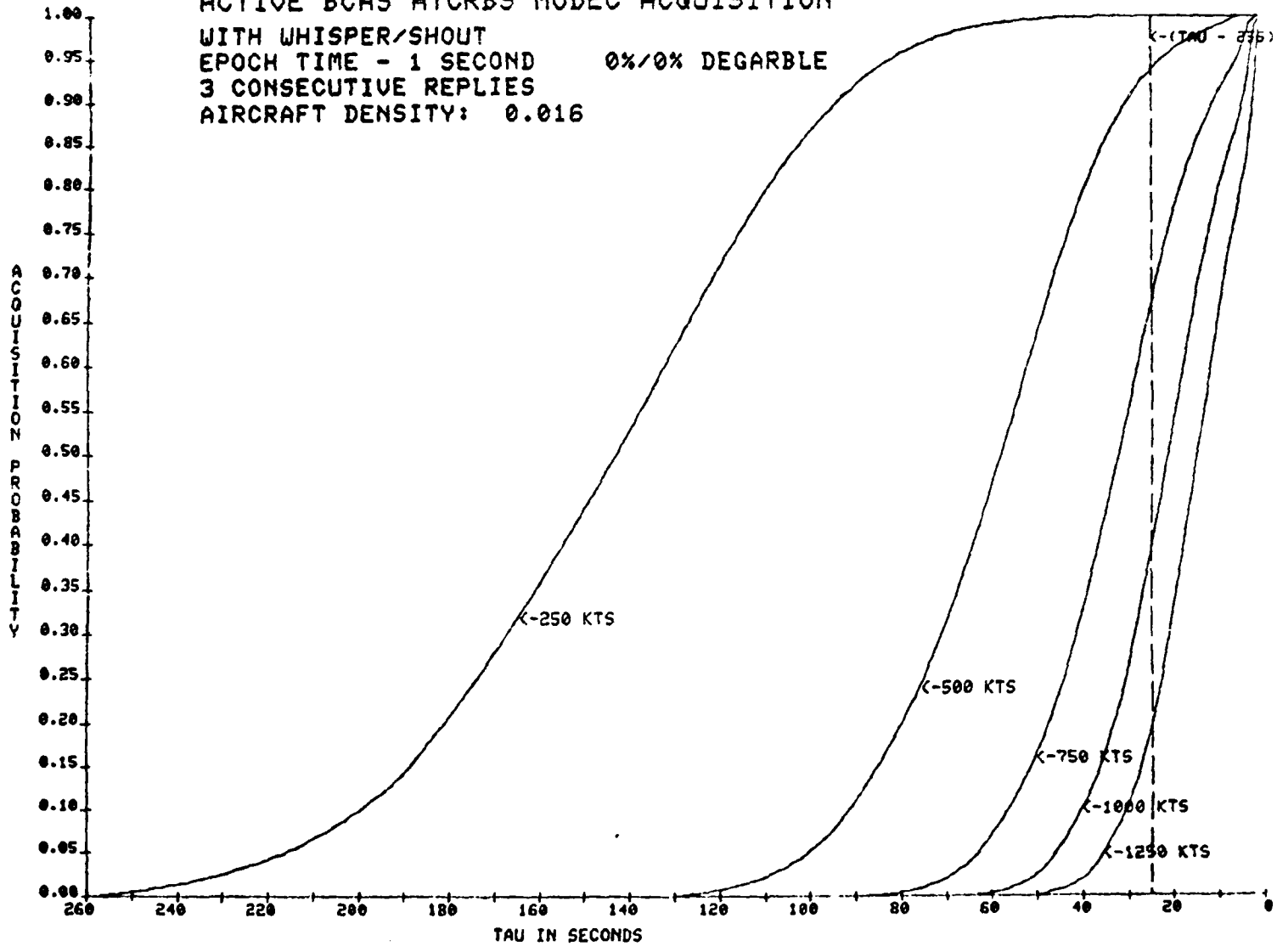

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 2SS)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

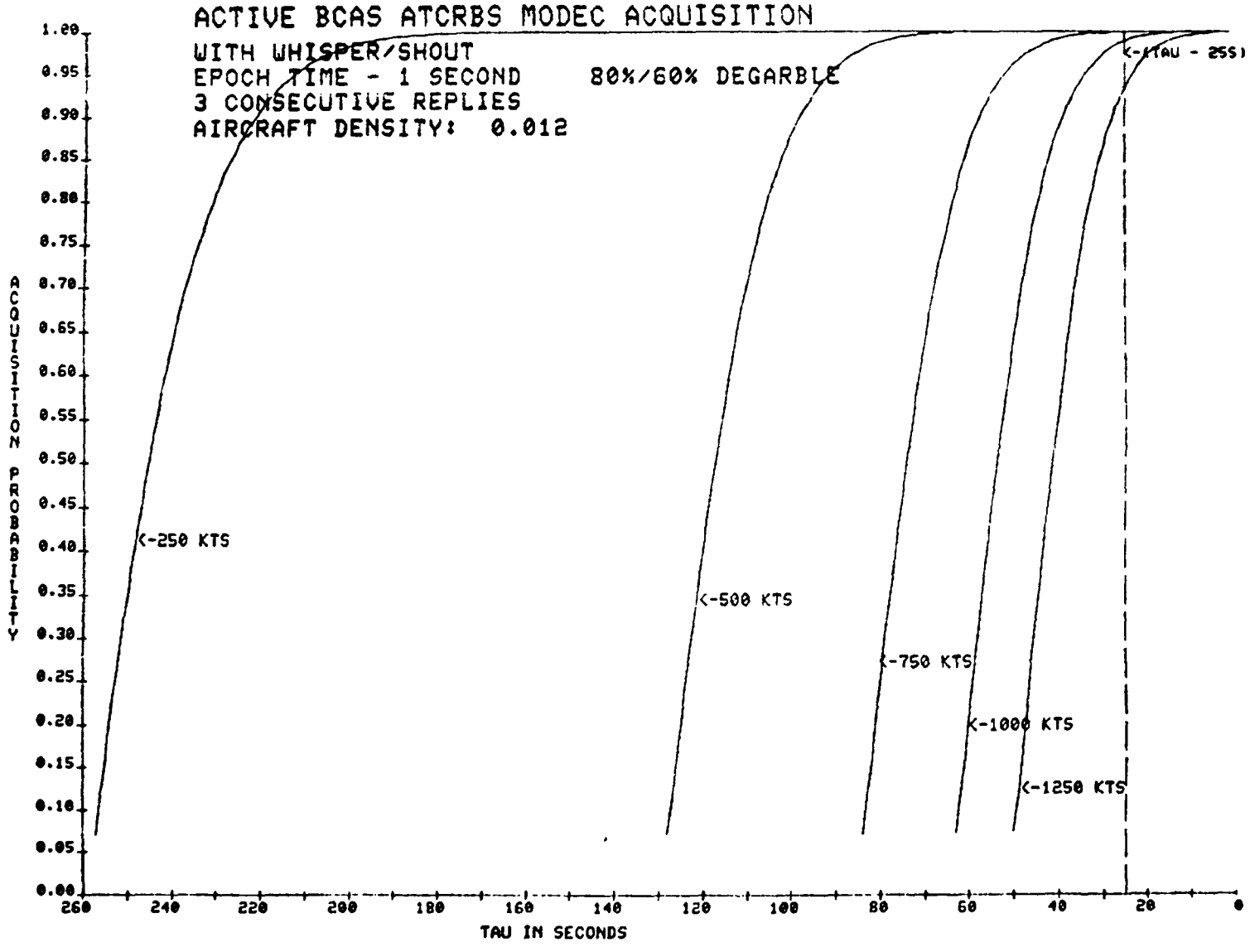

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
55%/0% DEGARBLE
ACQUISITION PROBABILITY
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-(TAU - 255)

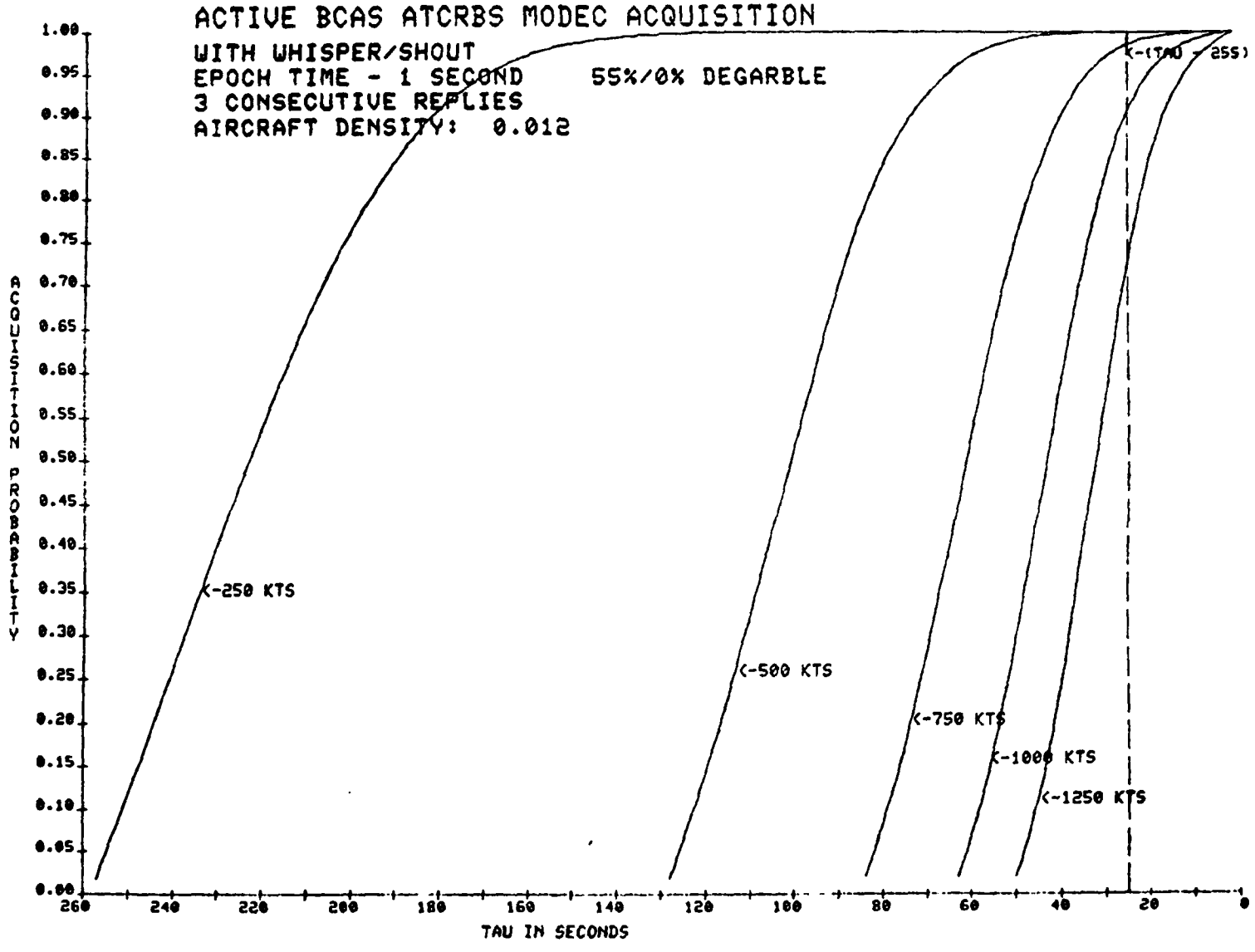

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU - 25S)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS

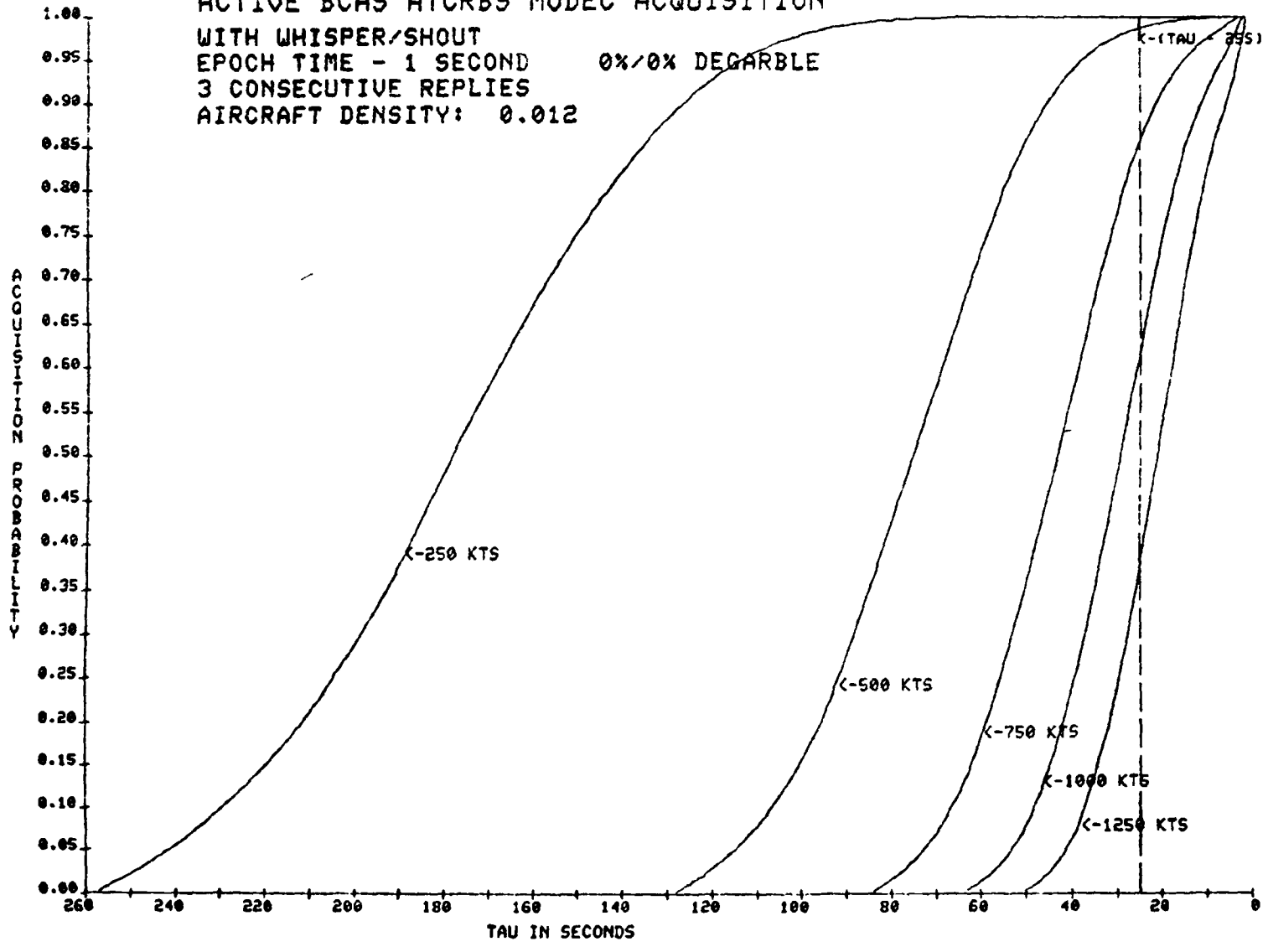

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-(TAU - 25S)

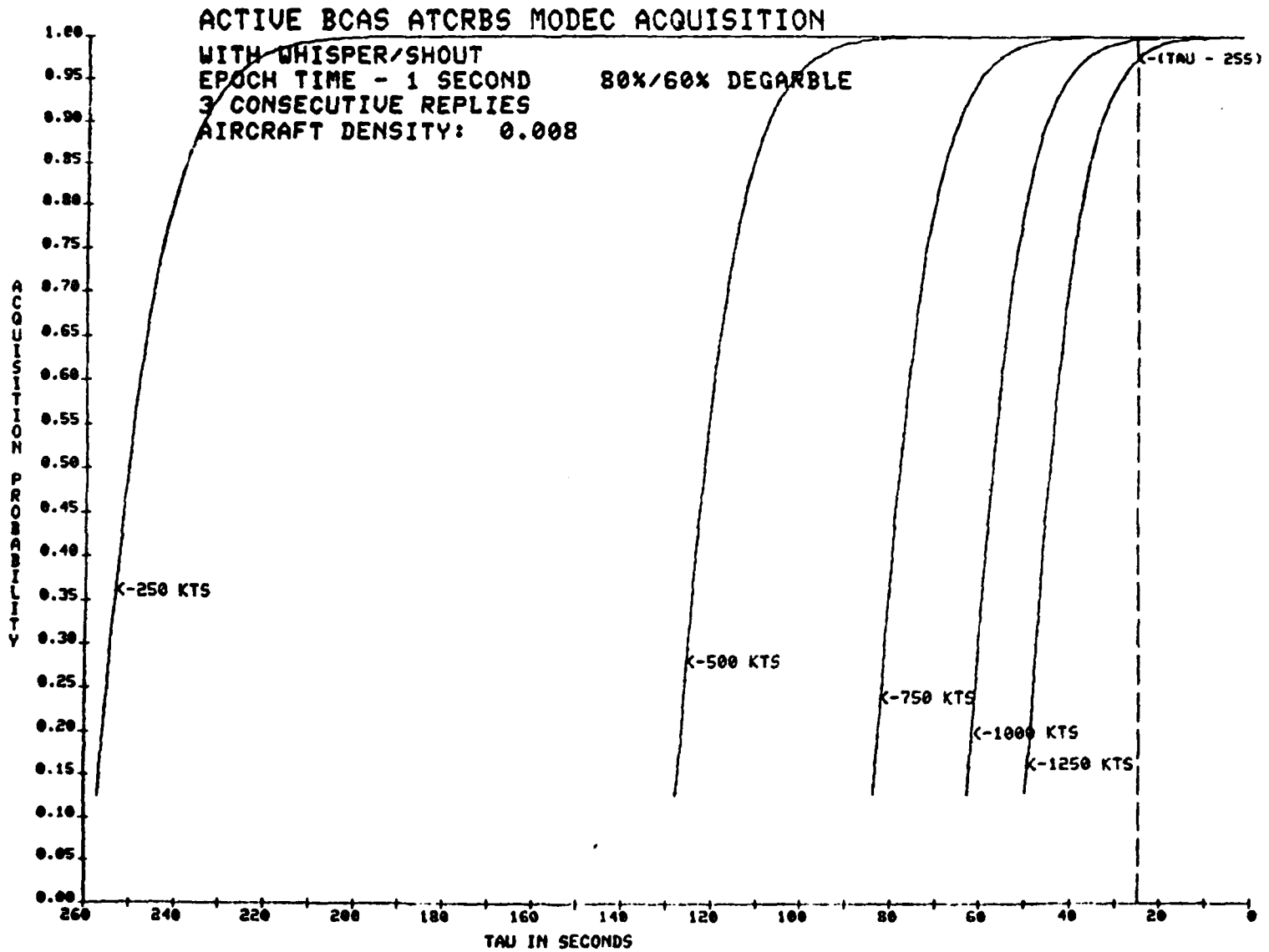

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
55%/0% DEGARBLE
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

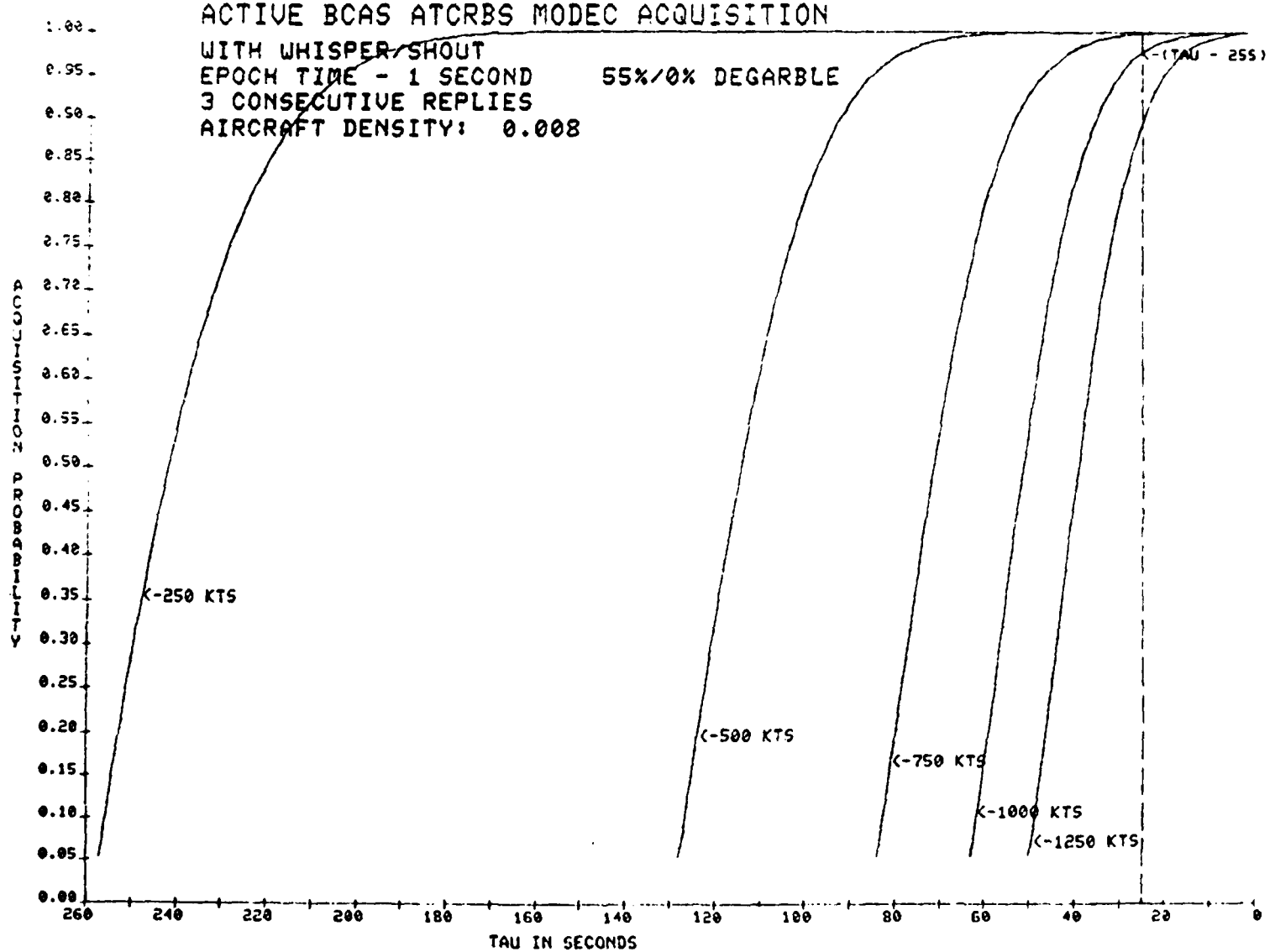

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS

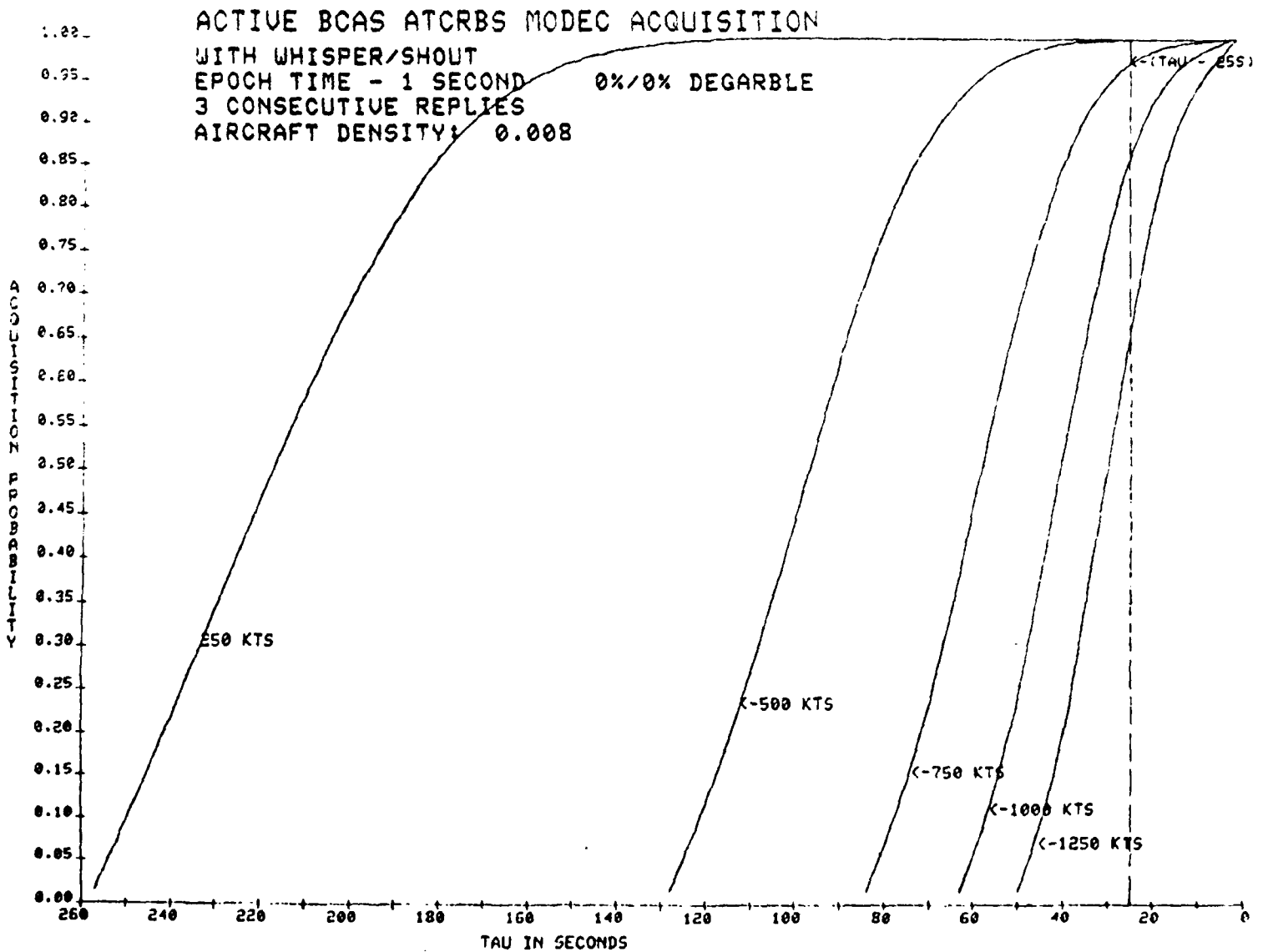

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU - 255)

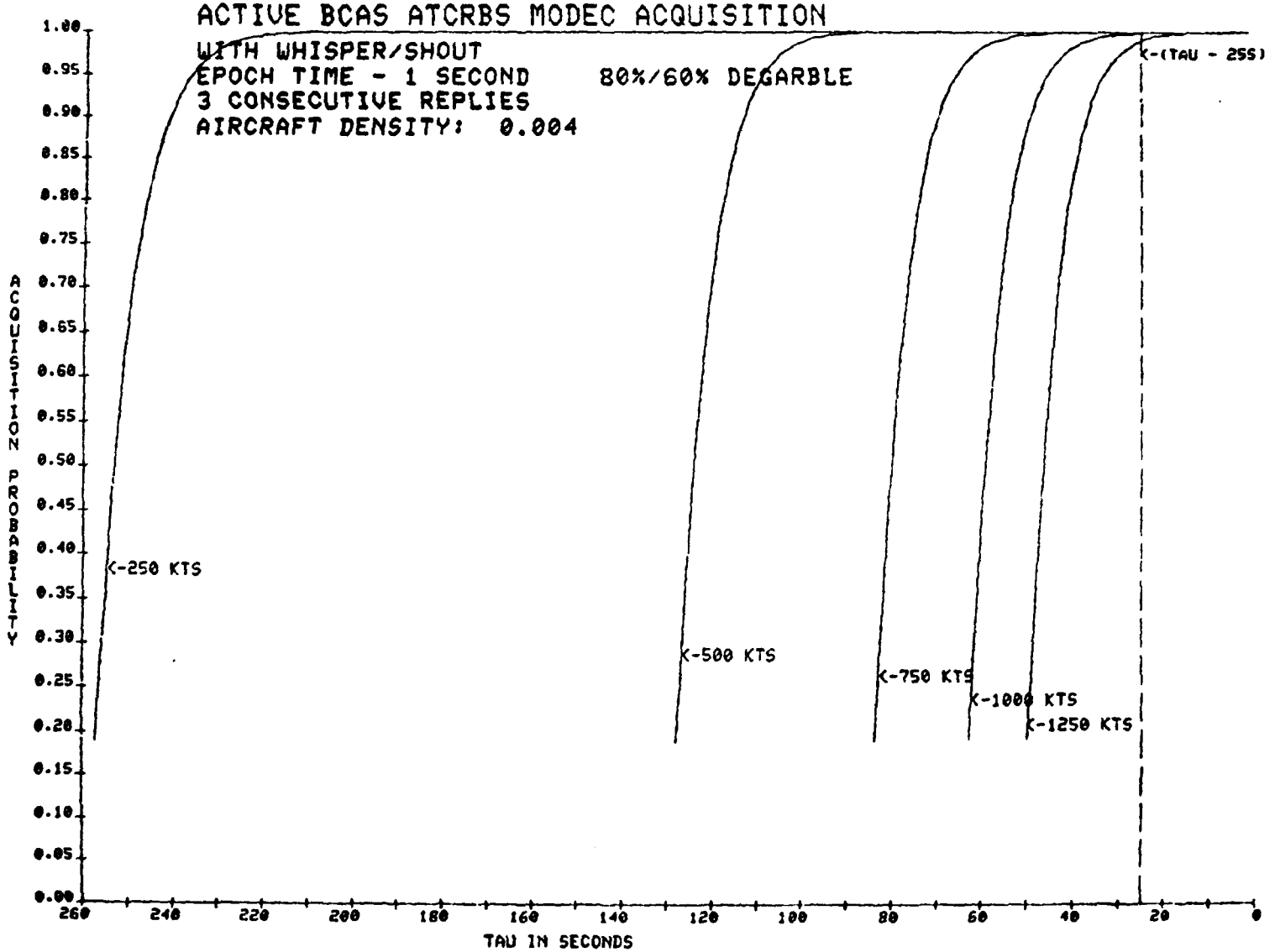

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU = 255)

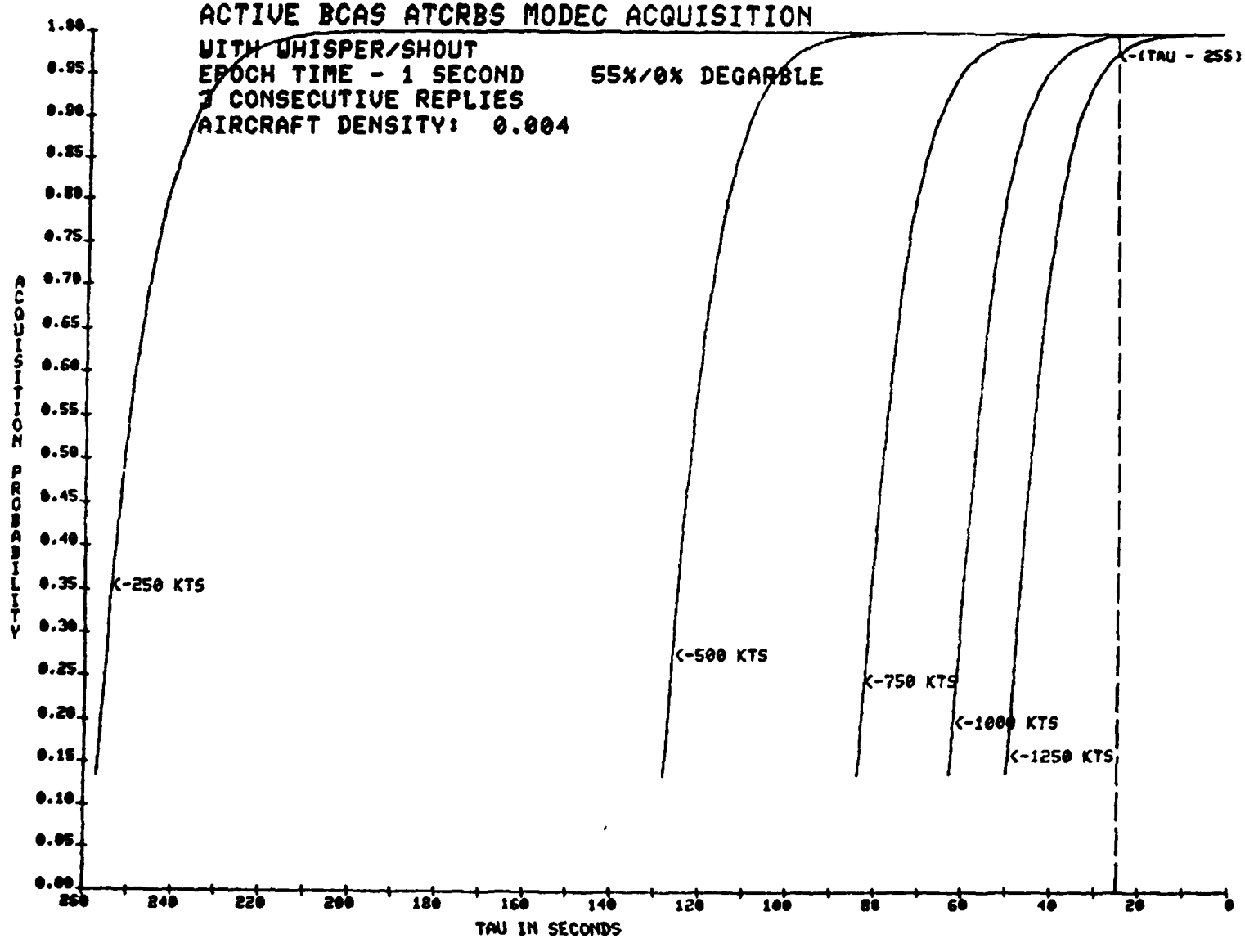

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU = 35S)

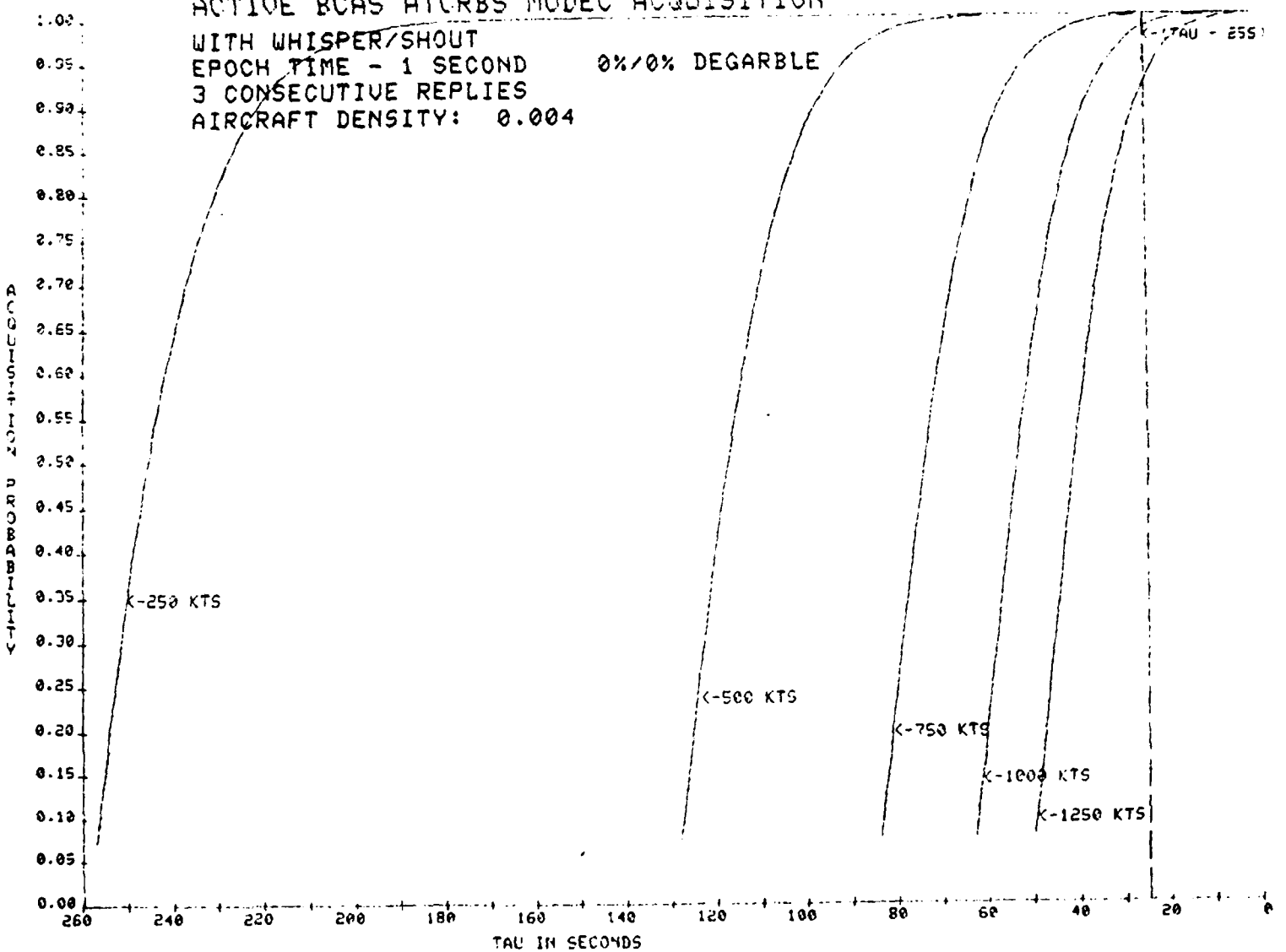

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-(TAU - 255)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS

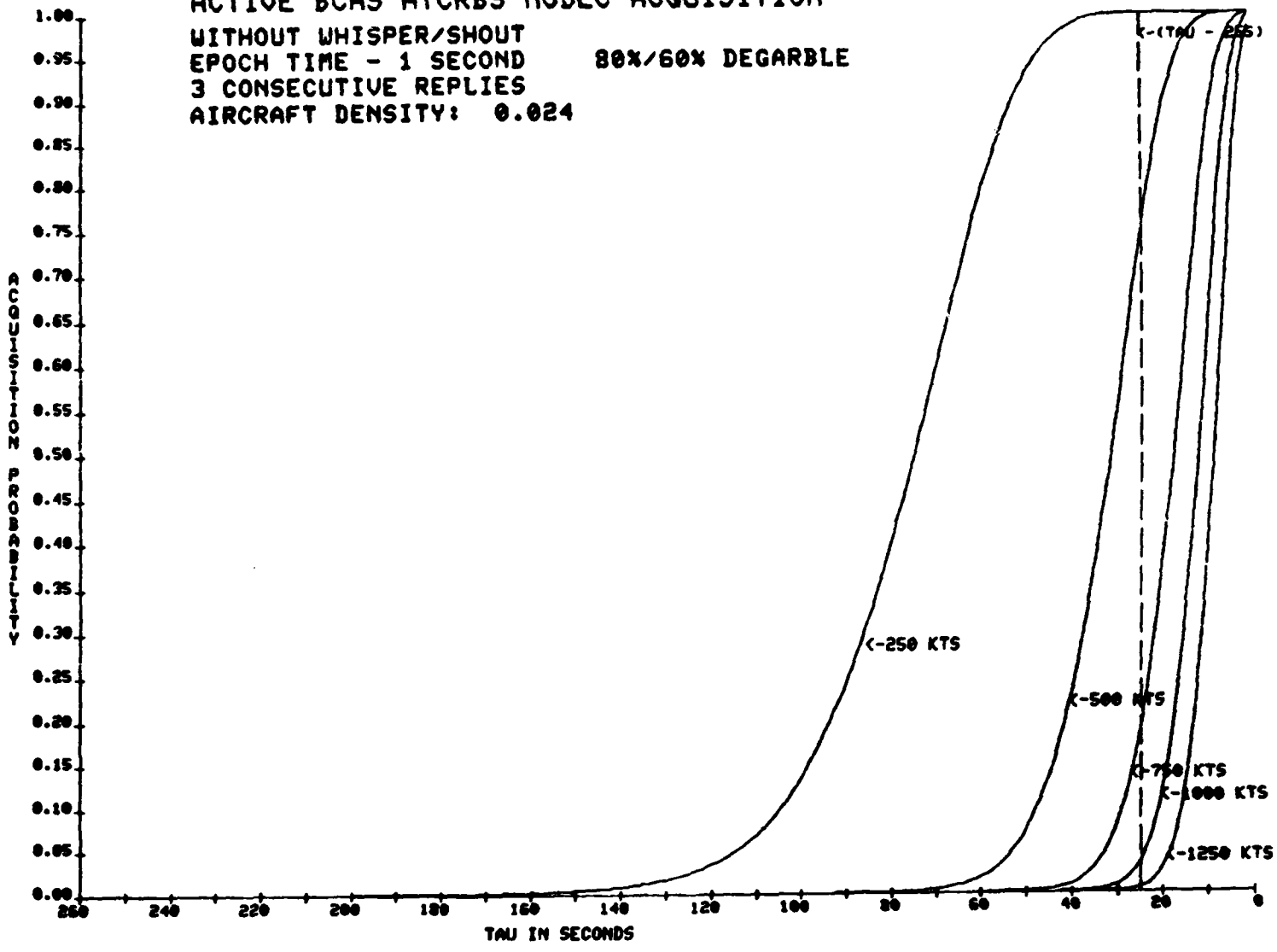

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU - 255)

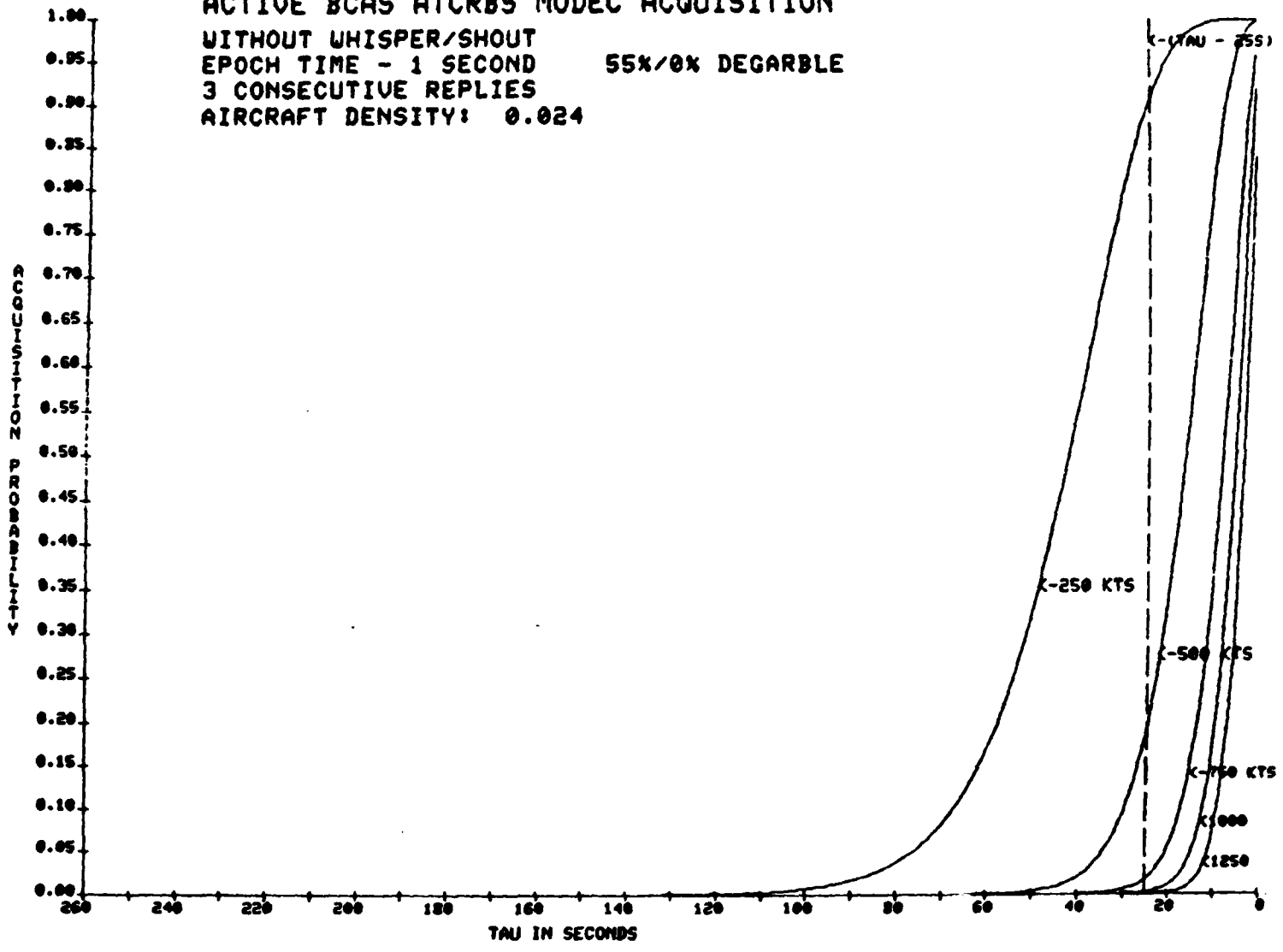

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<(TAU - ESS)
ESO KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

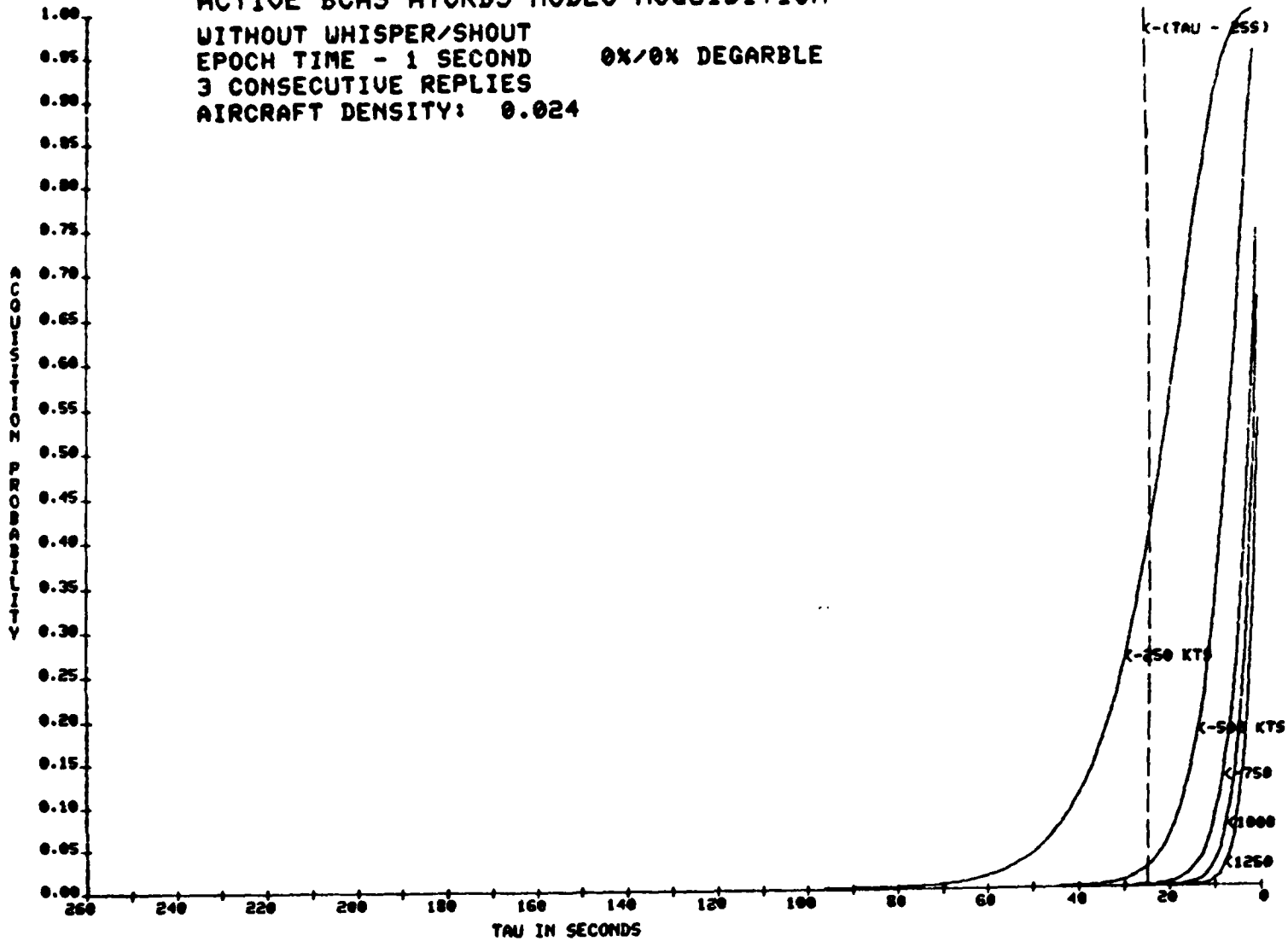

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
80%/60% DEGARBLE
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU - 255)

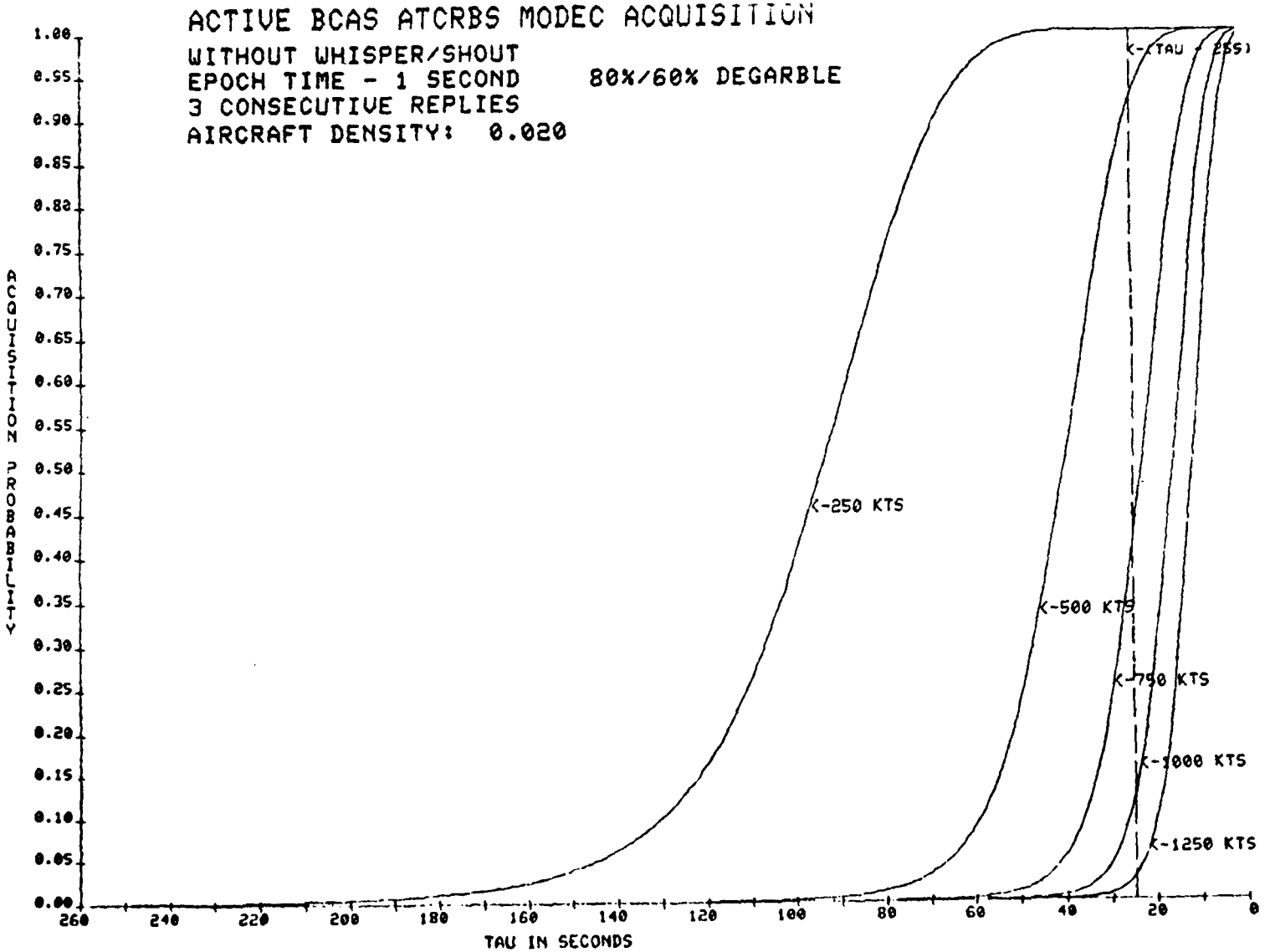

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 25S)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

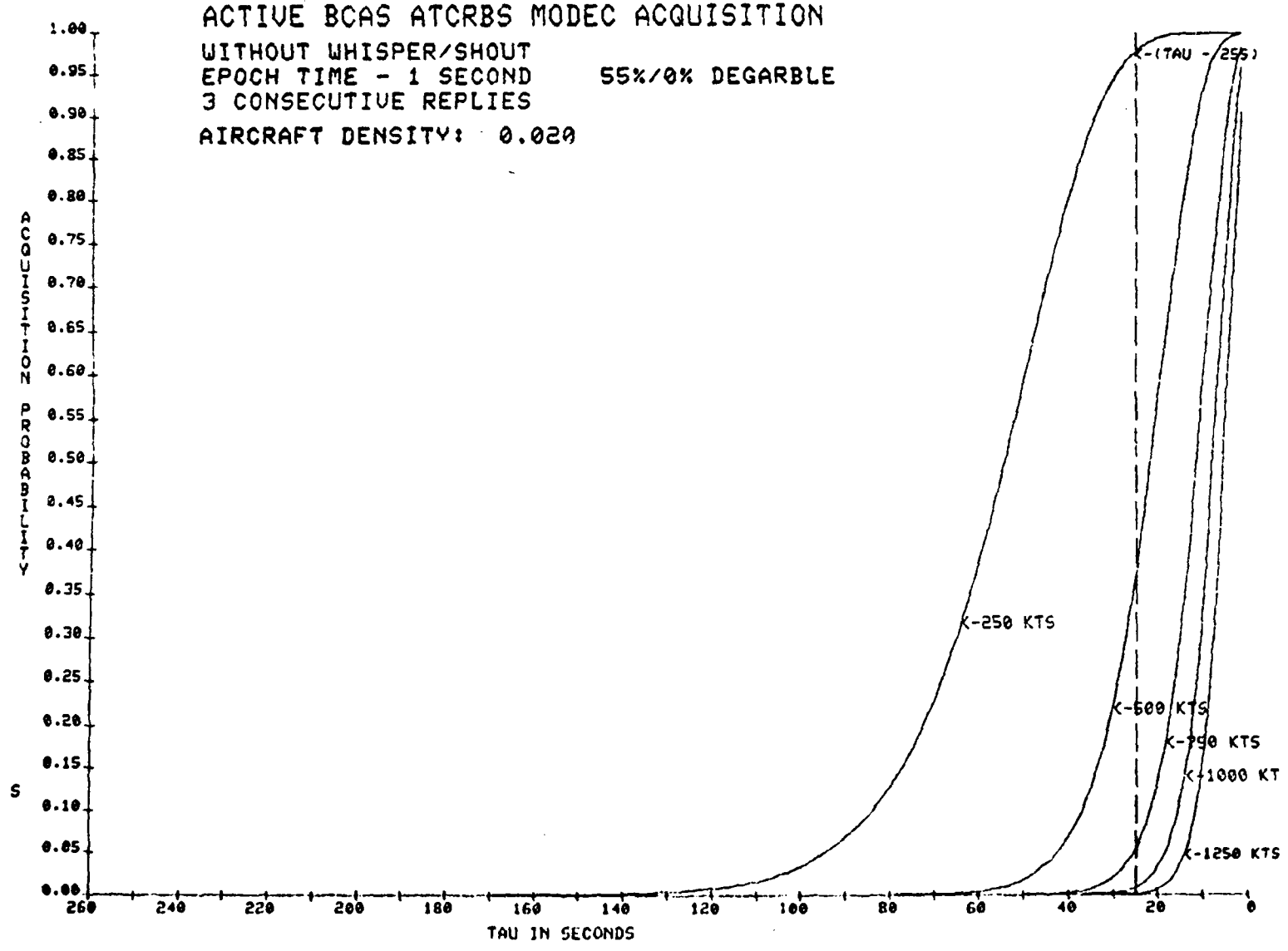

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-TAU - 255

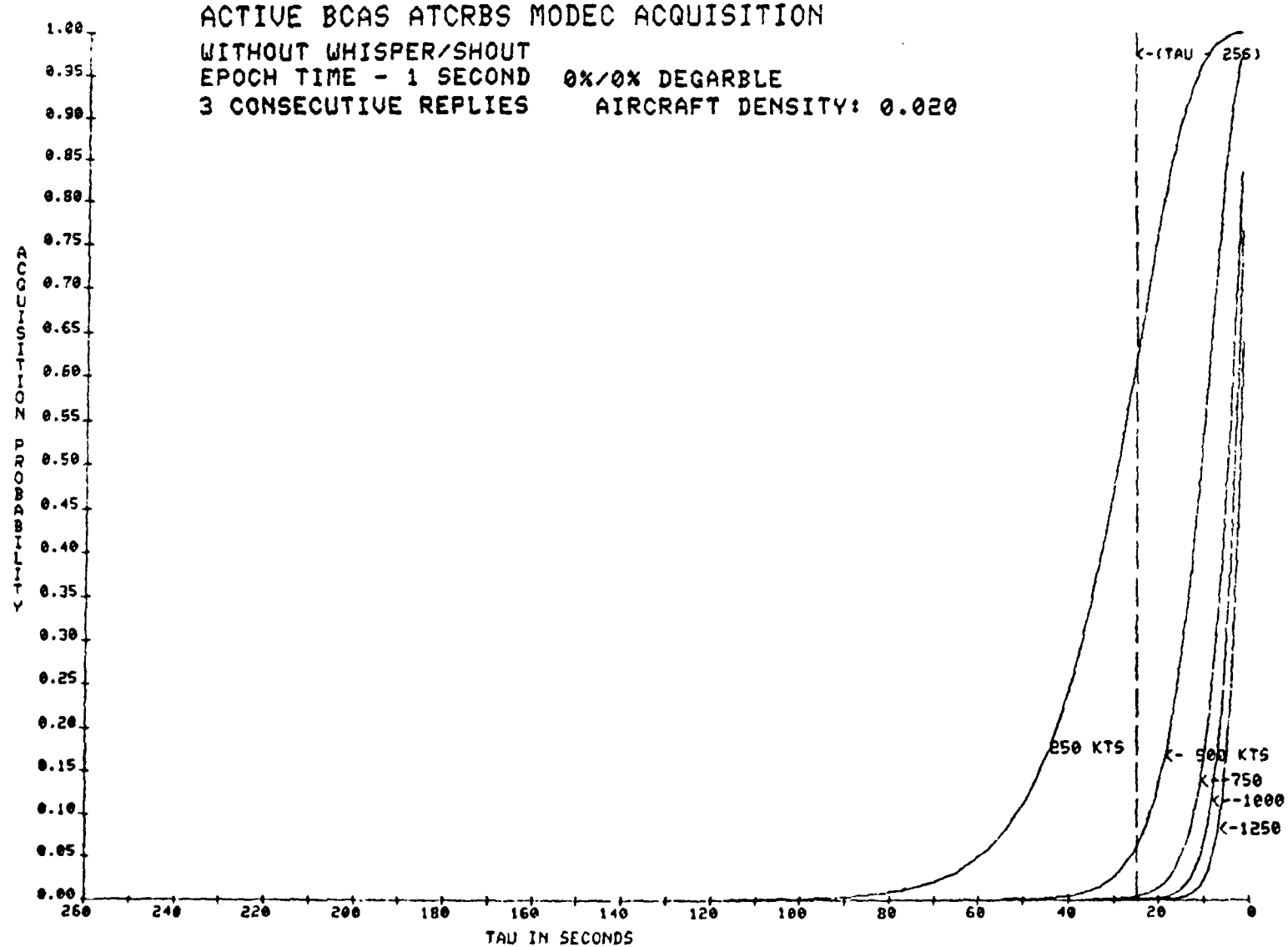

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

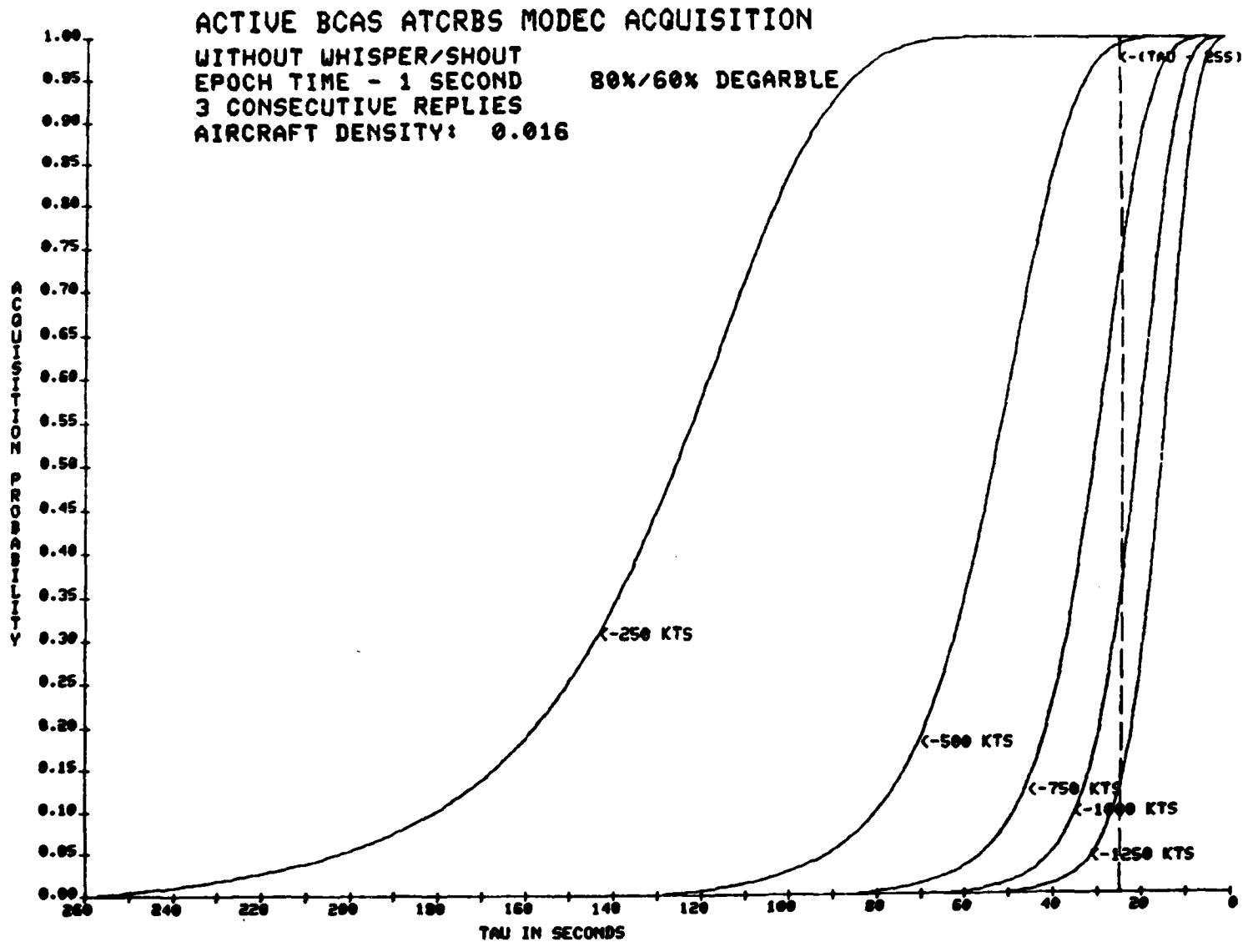

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K1000
K1250

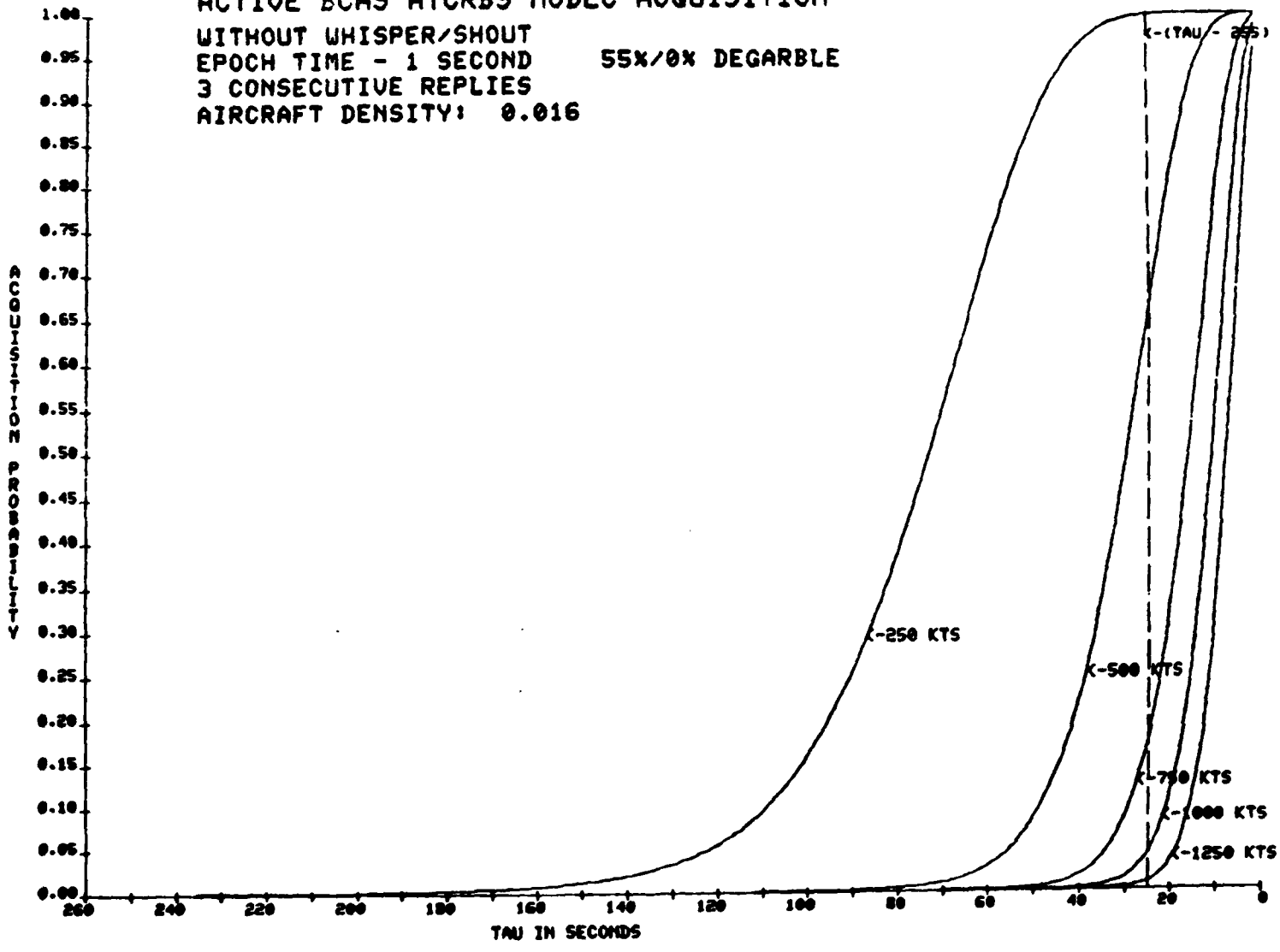

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
750
1000
1250

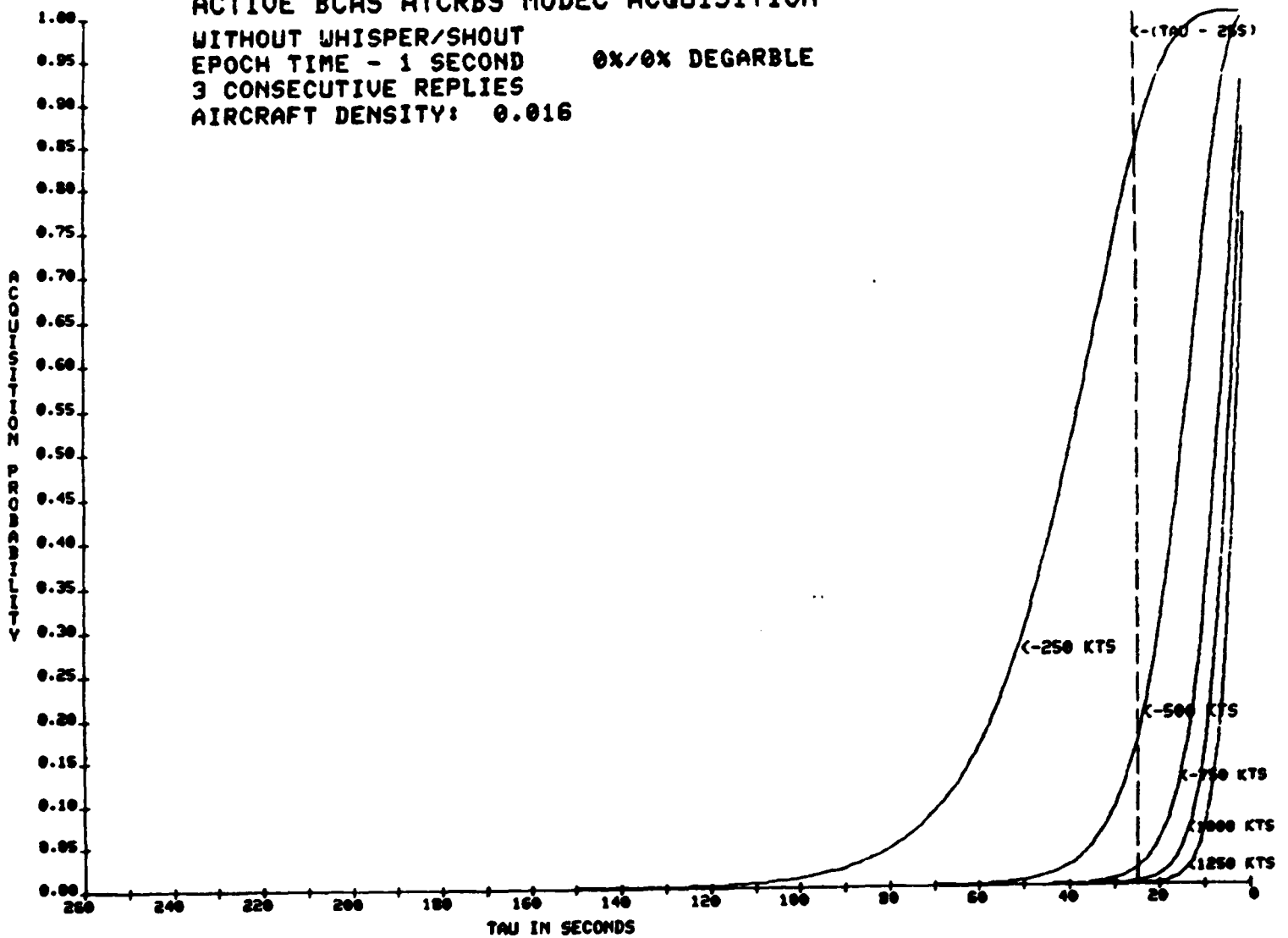

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU + 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS

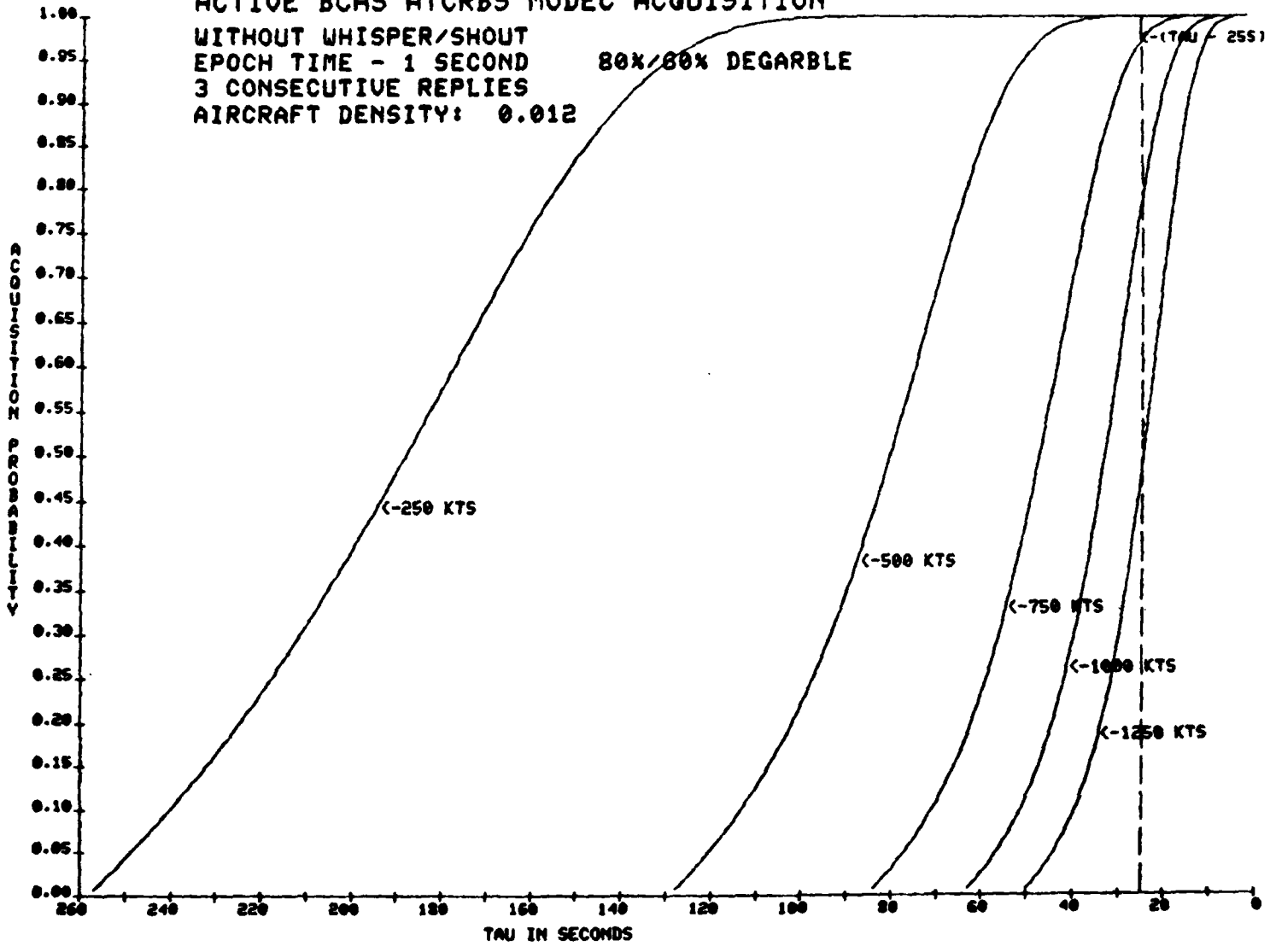

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KT
K-1250 KTS

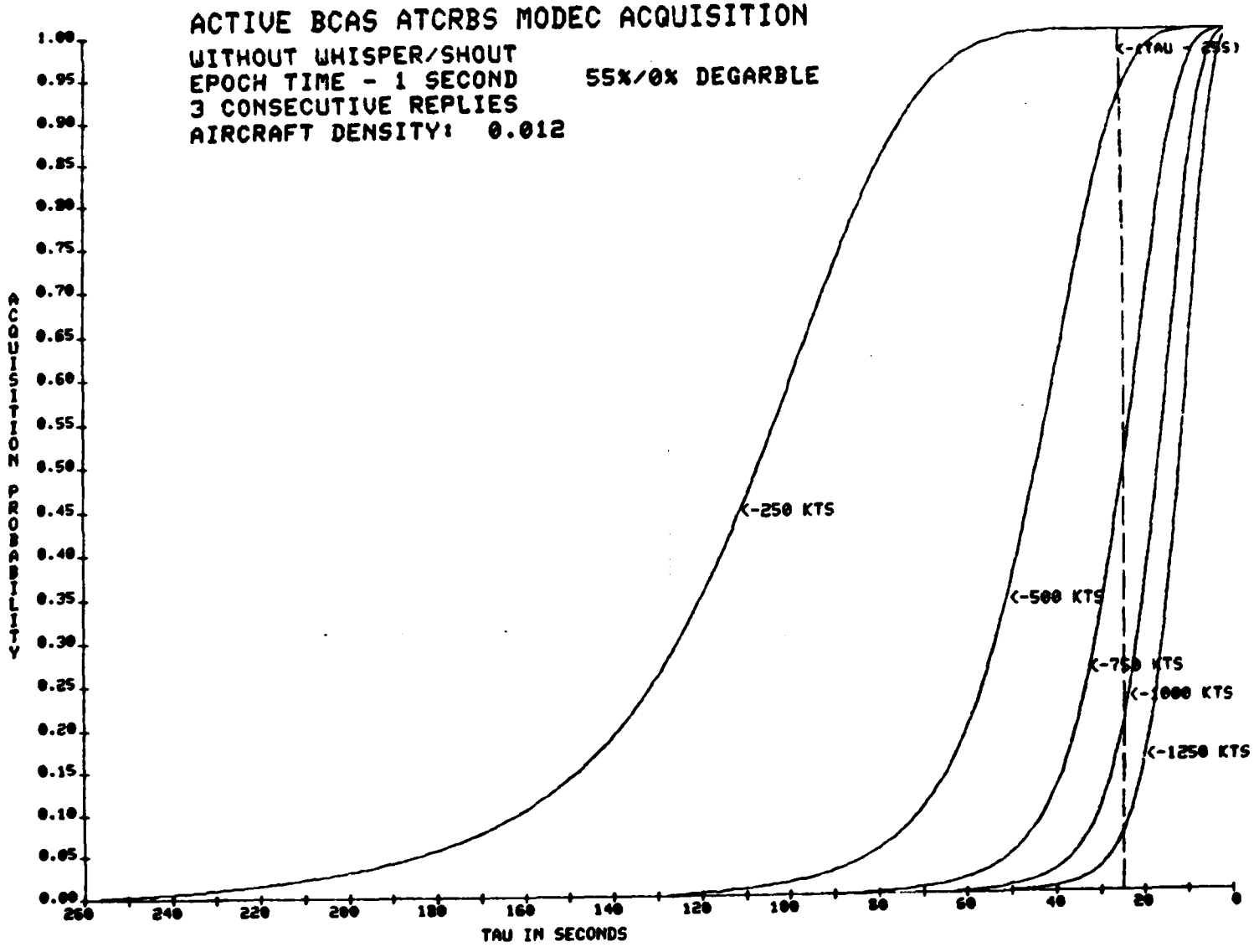

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 256)
250 KTS
K- 500 KTS
K--750
K--1000
K-1250

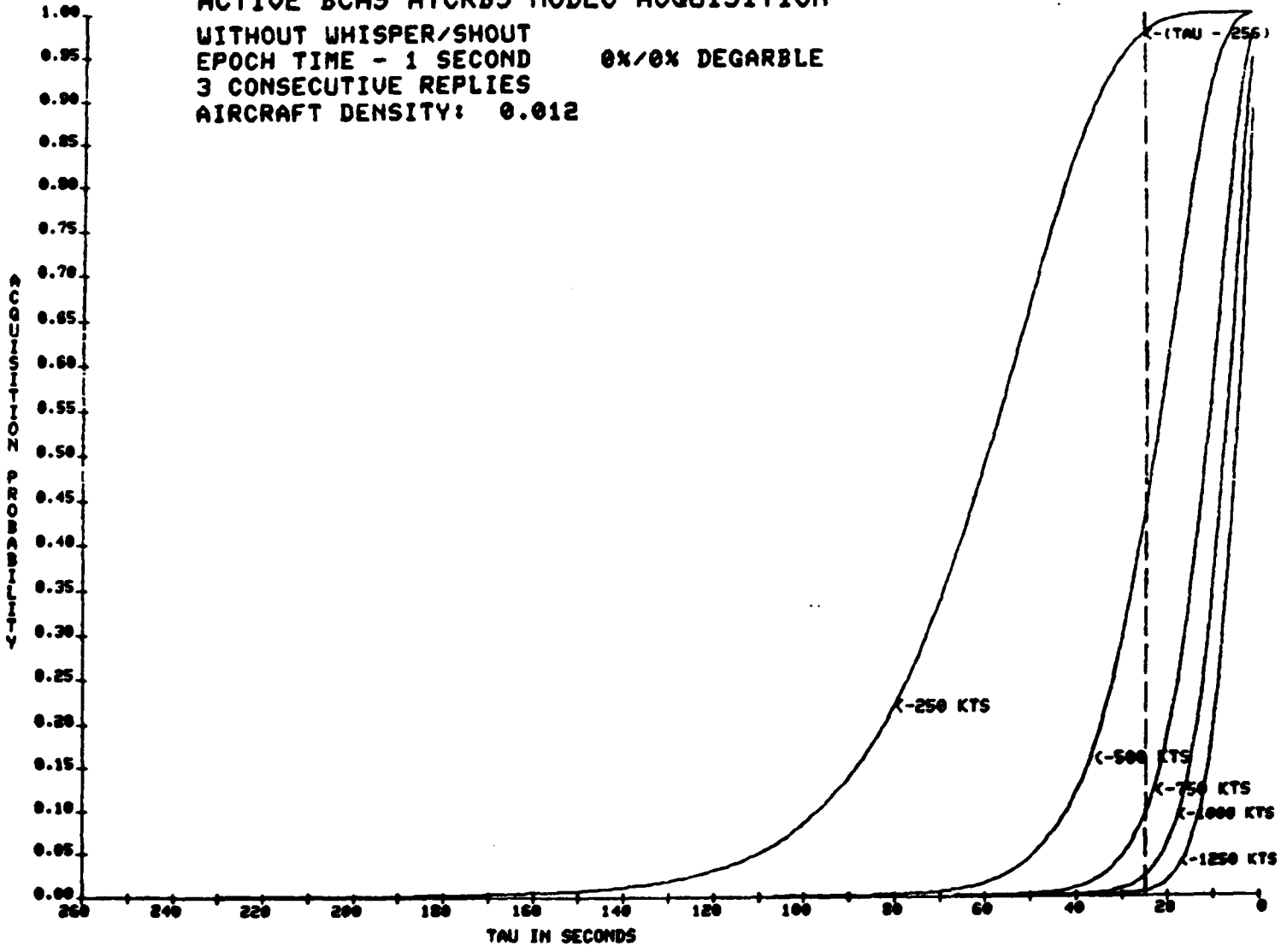

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
80%/60% DEGARBLE
ACQUISITION PROBABILITY
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

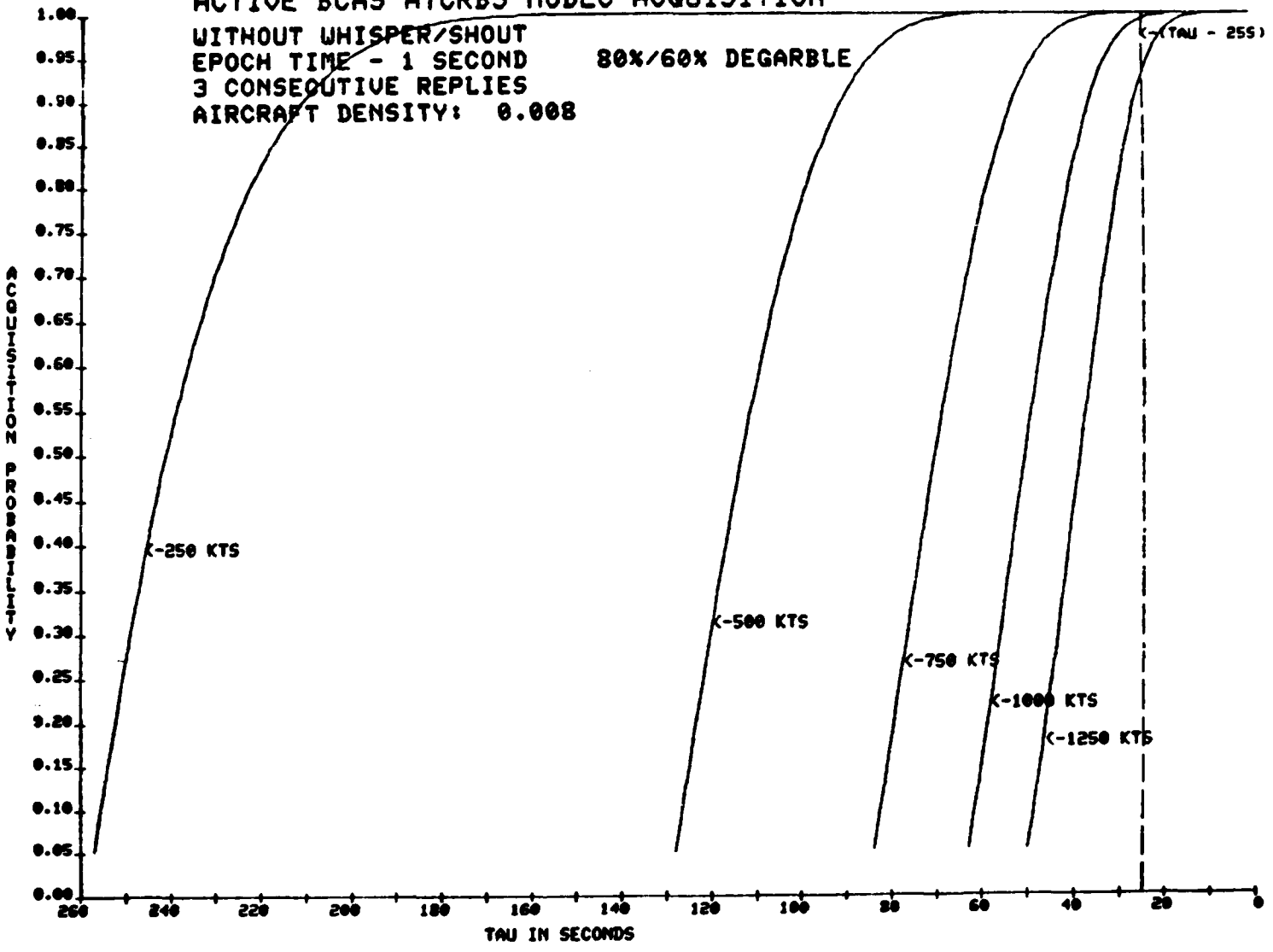

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
(-(TAU - 255)
(-250 KTS
(-500 KTS
(-750 KTS
(-1000 KTS
(-1250 KTS

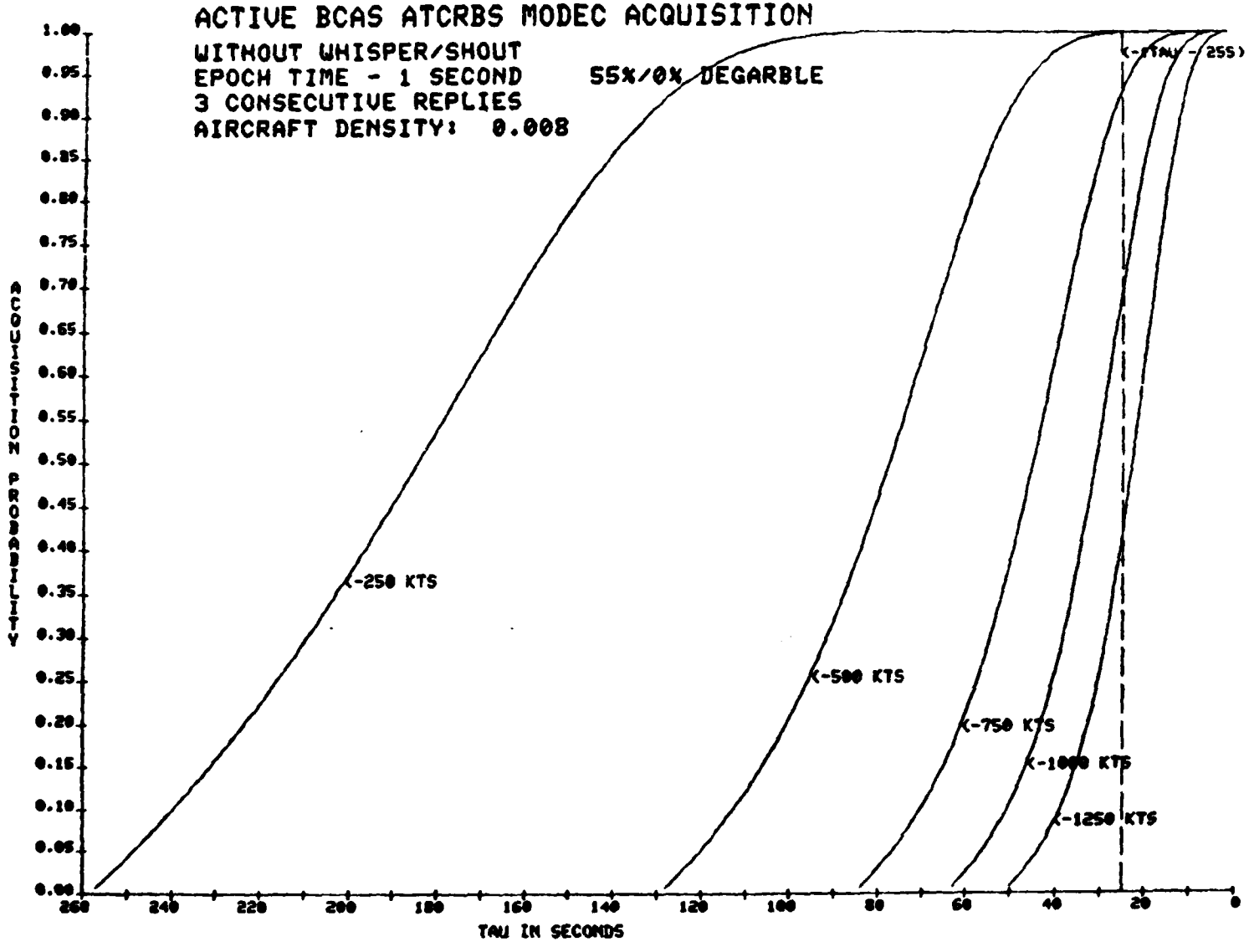

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<1000 KTS
<1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/80% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS
<-(TAU = 255)


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-TAU = 25S)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
(-(TAU - 256)
(-250 KTS
(-500 KTS
(-750 KTS
(-1000 KTS
(-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
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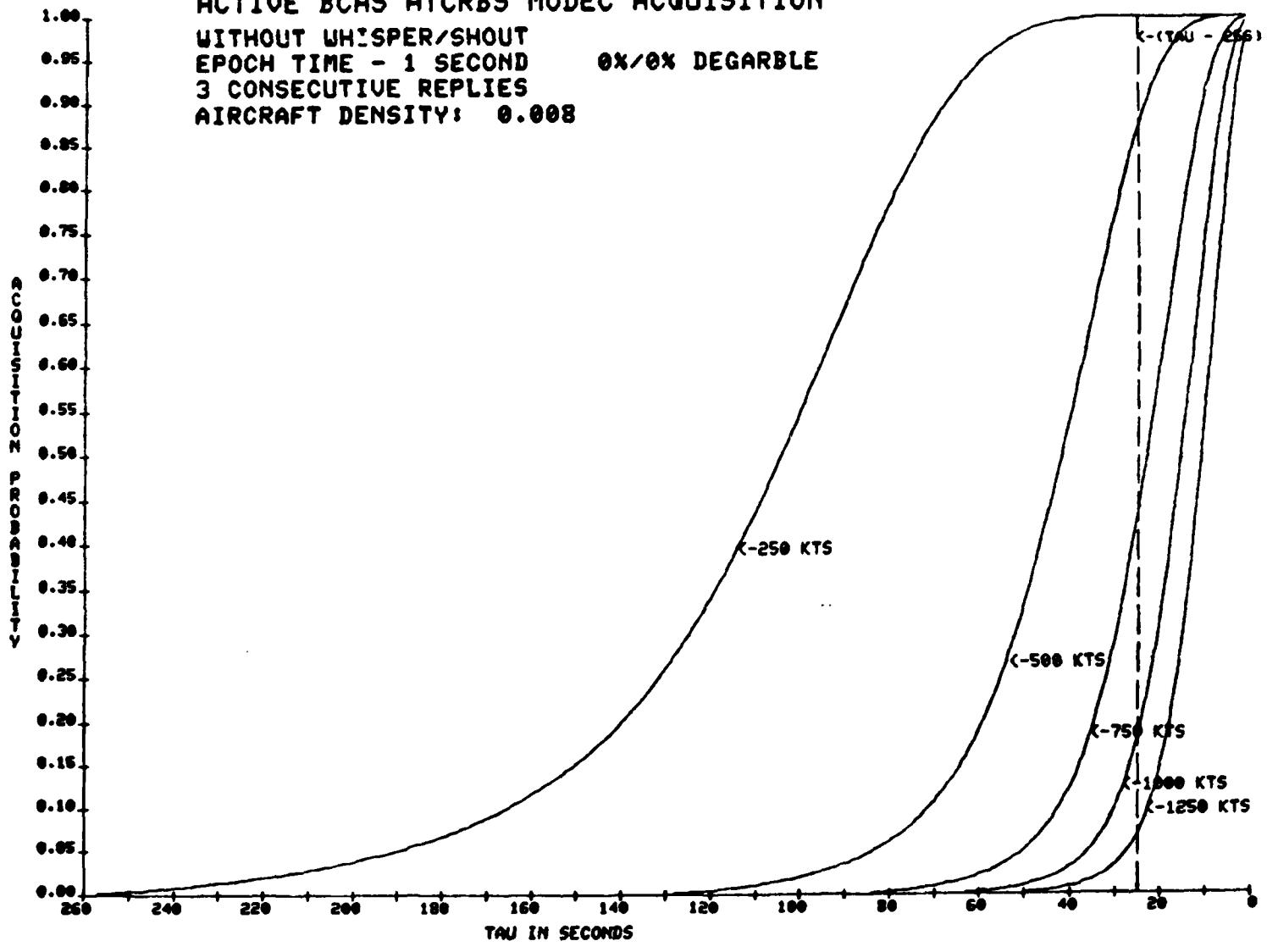
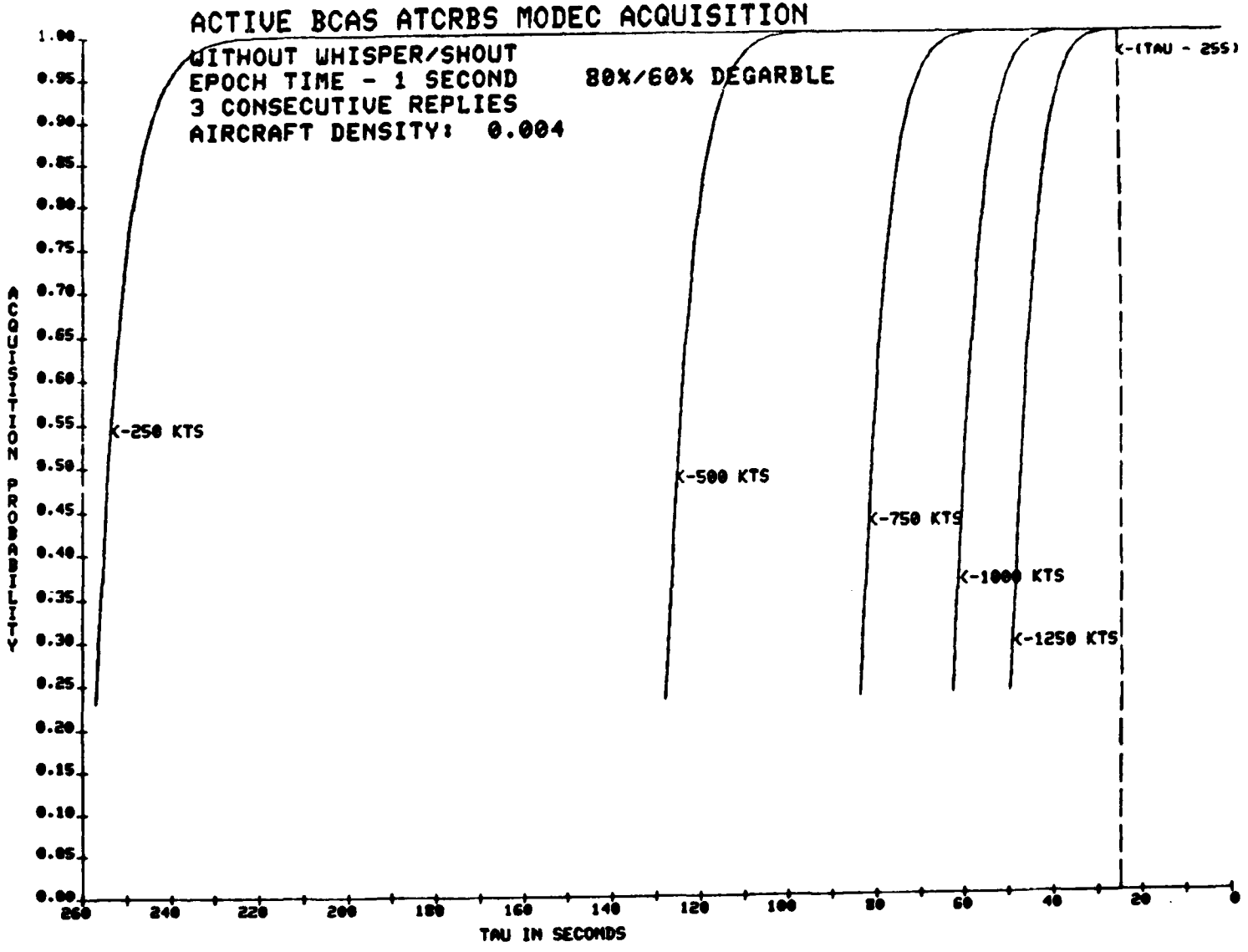
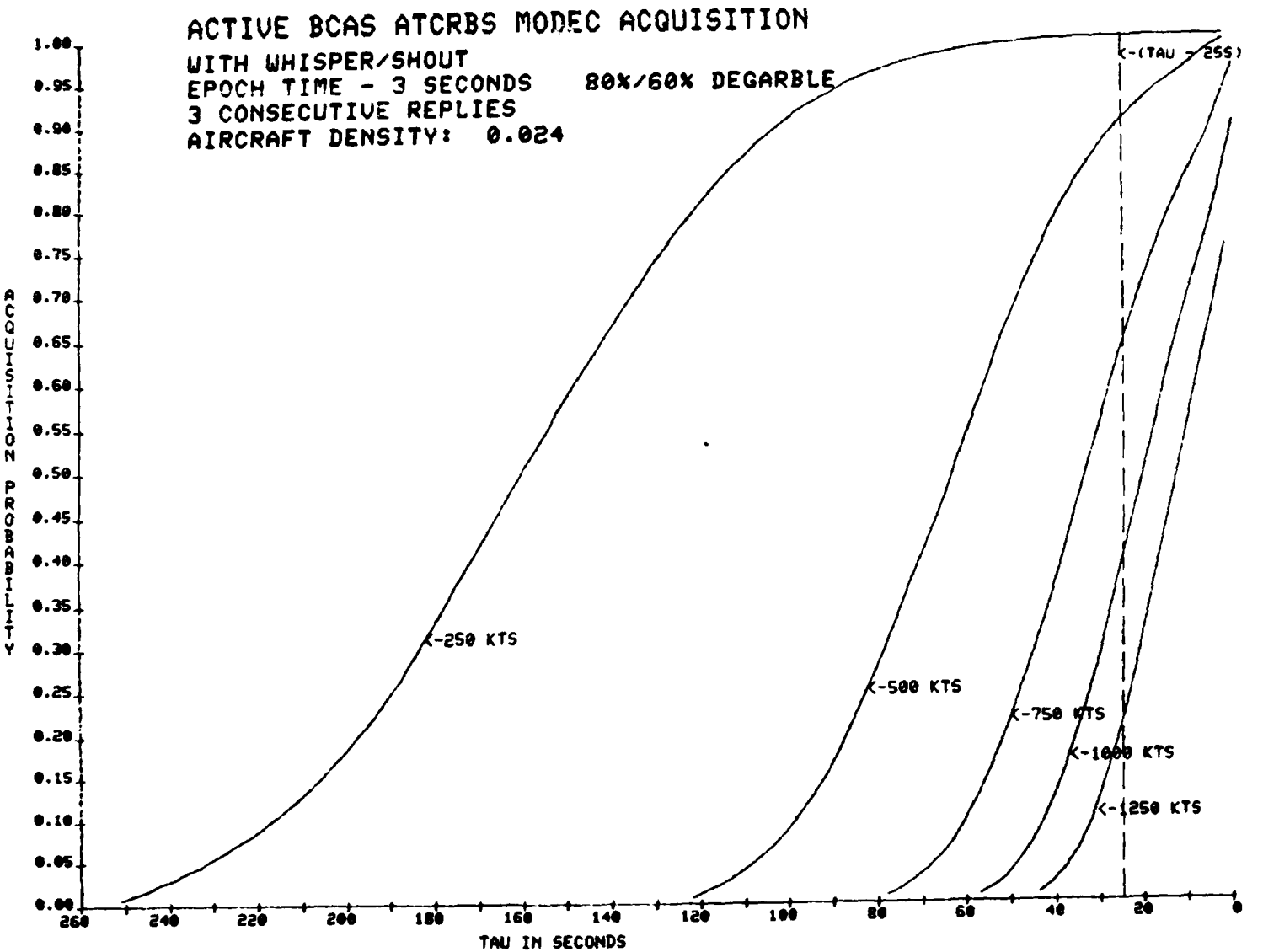
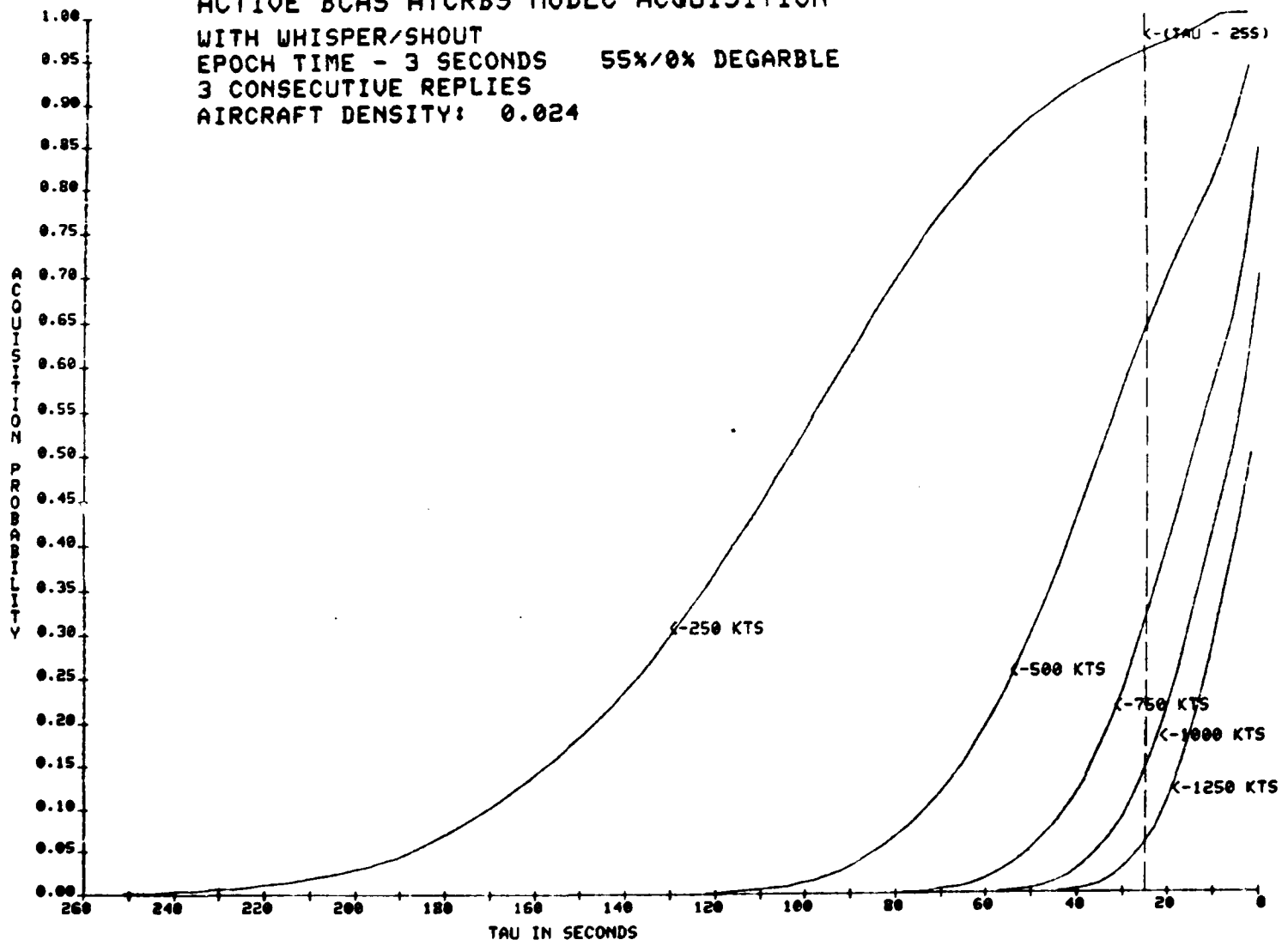
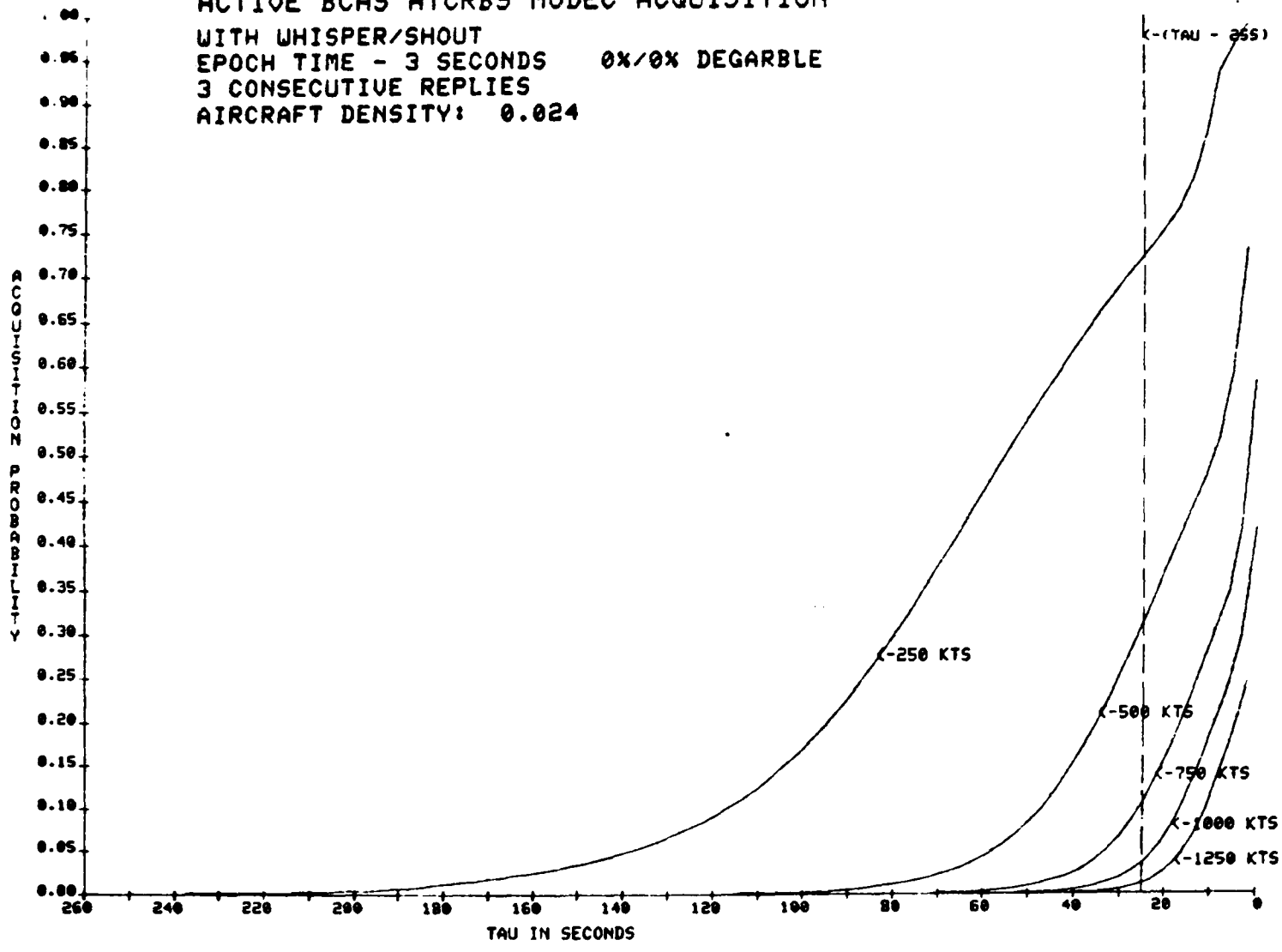
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1250 KTS

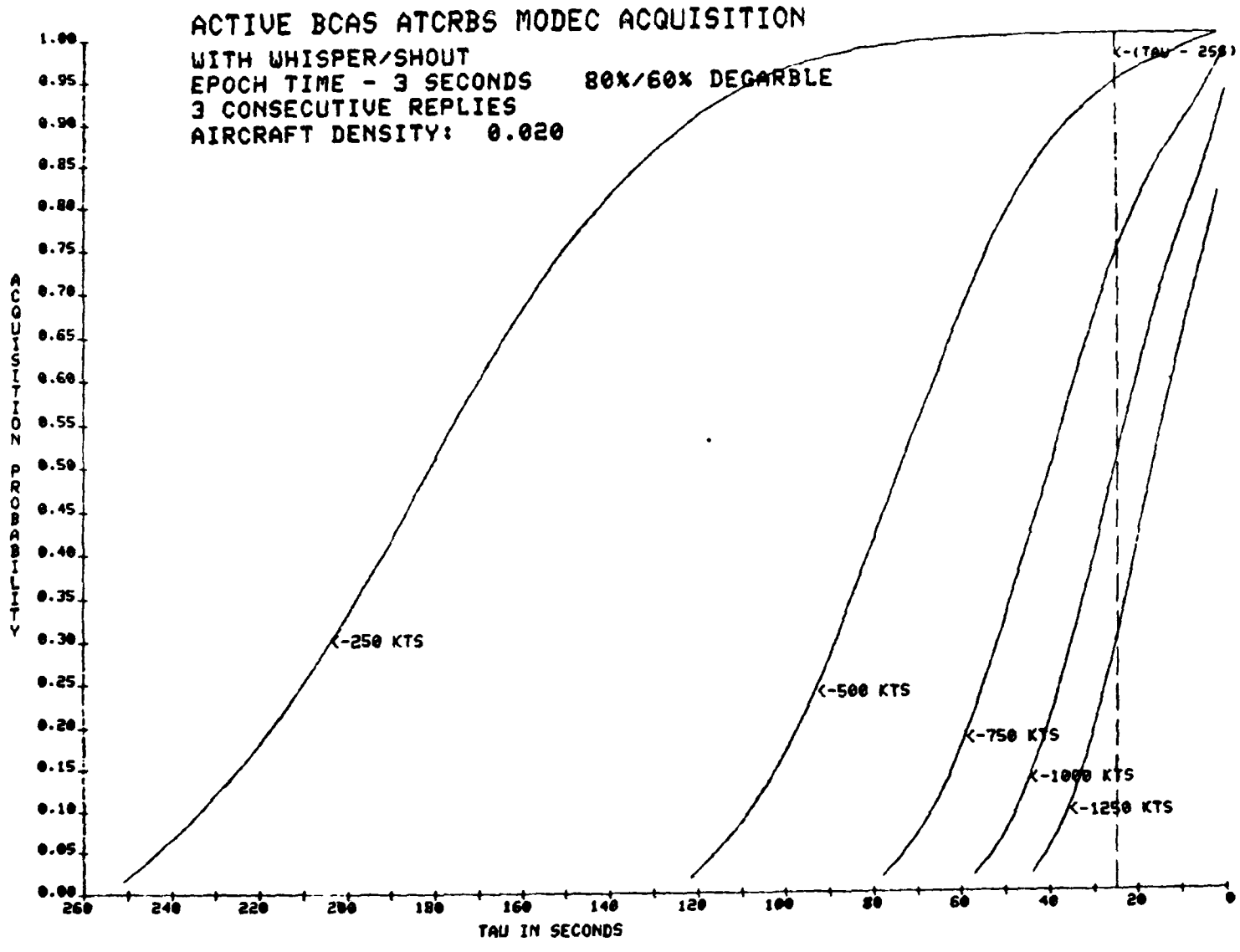

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 256)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

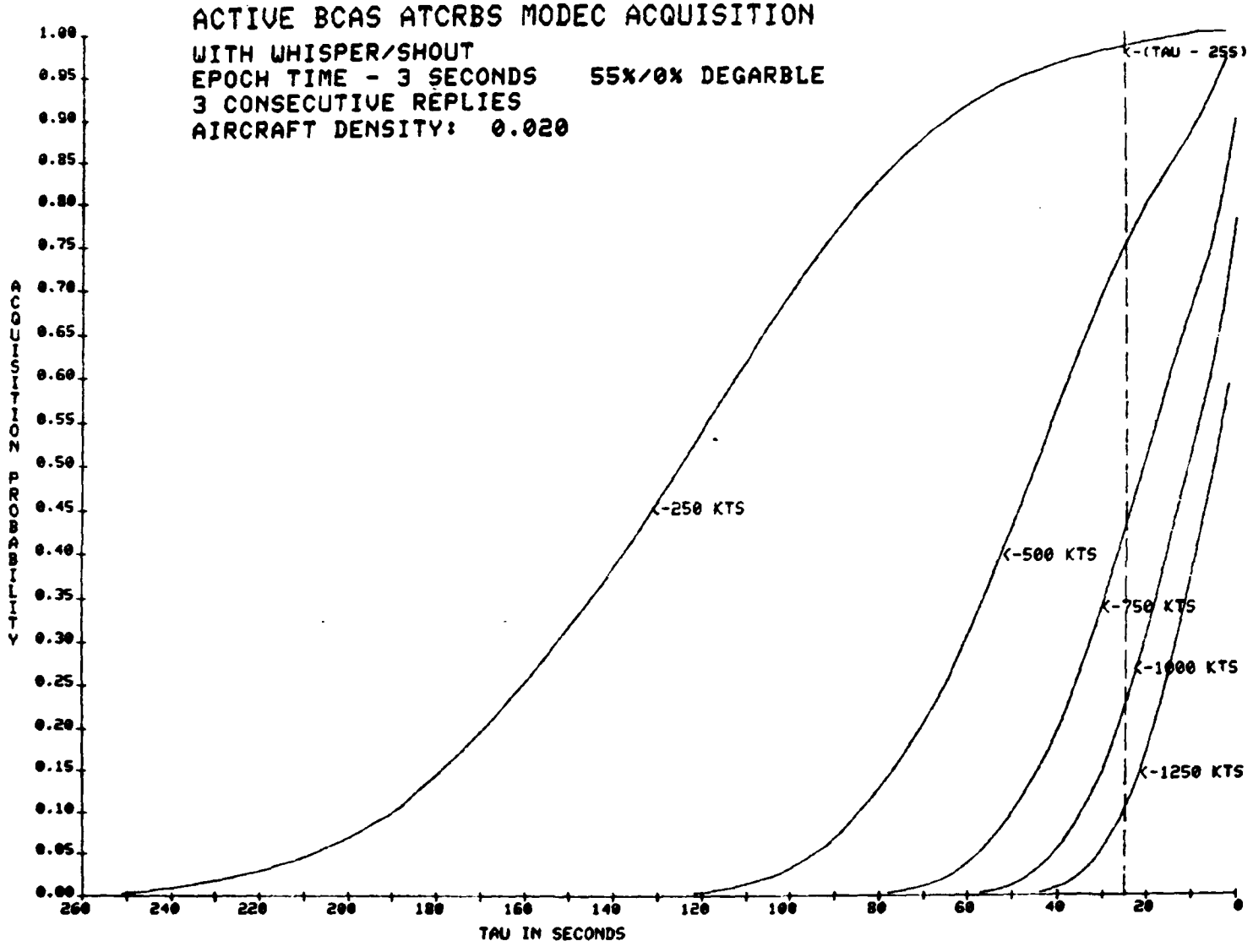

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 1 SECOND
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
80%/60% DEGARBLE
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS

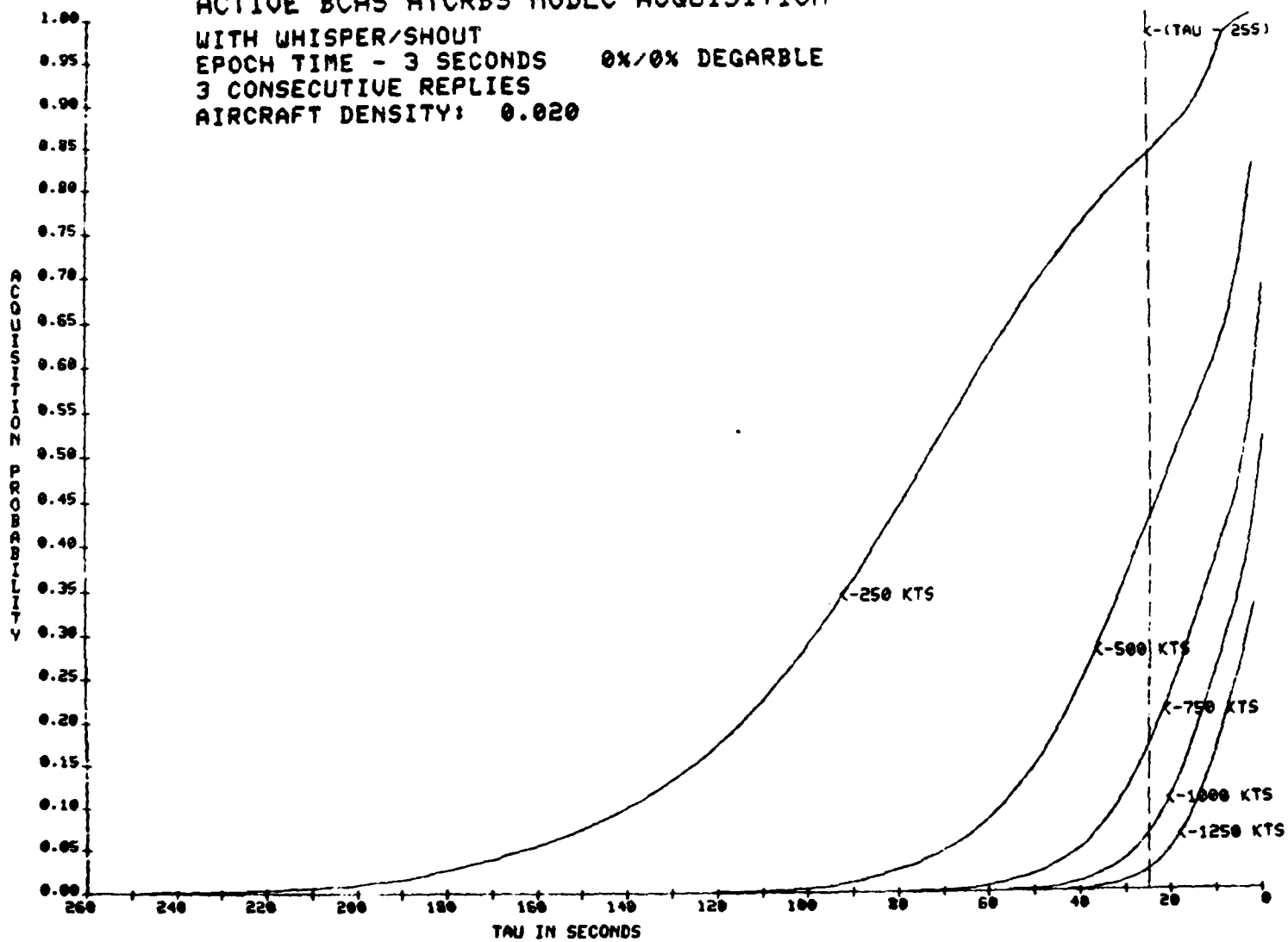

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU = 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS

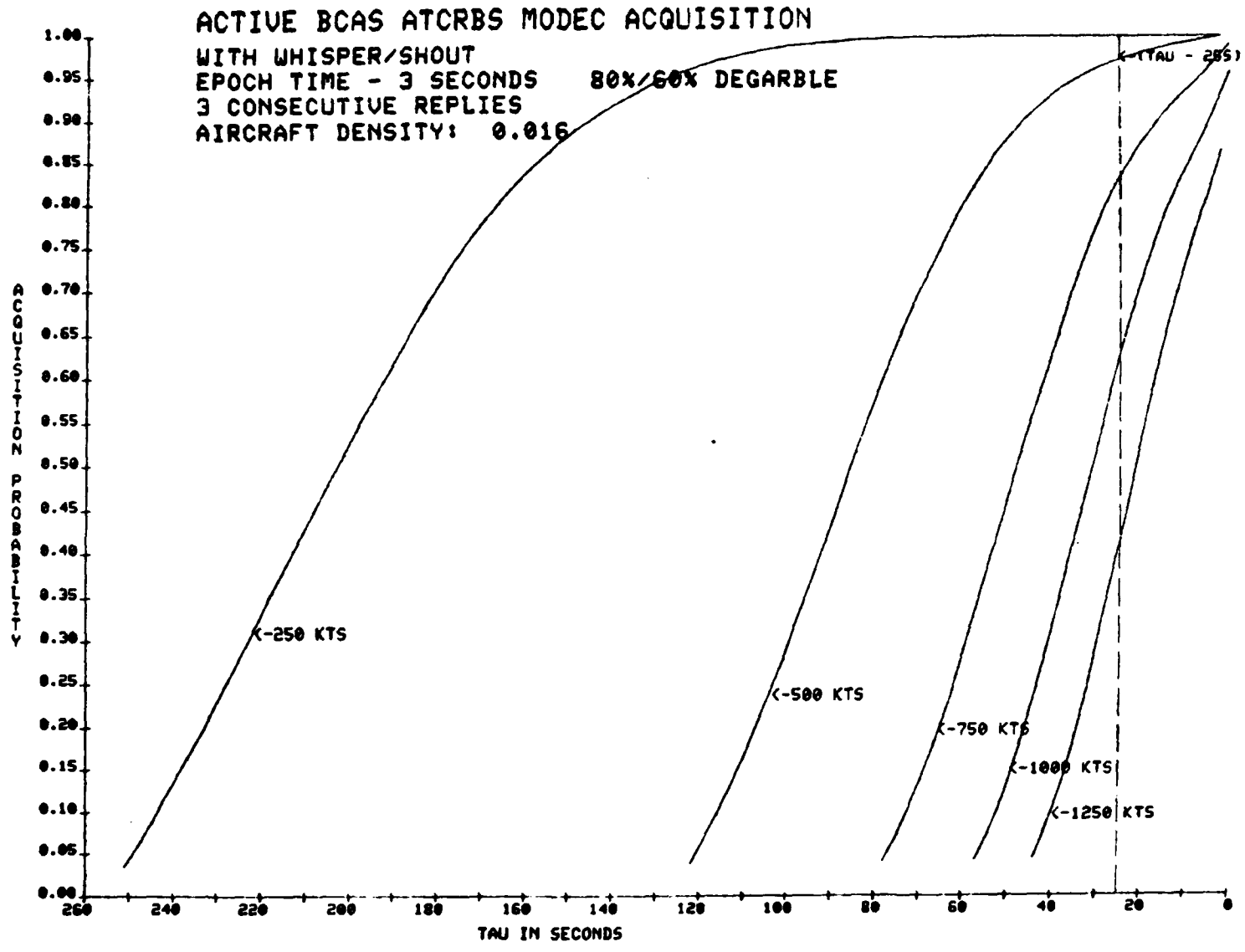

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

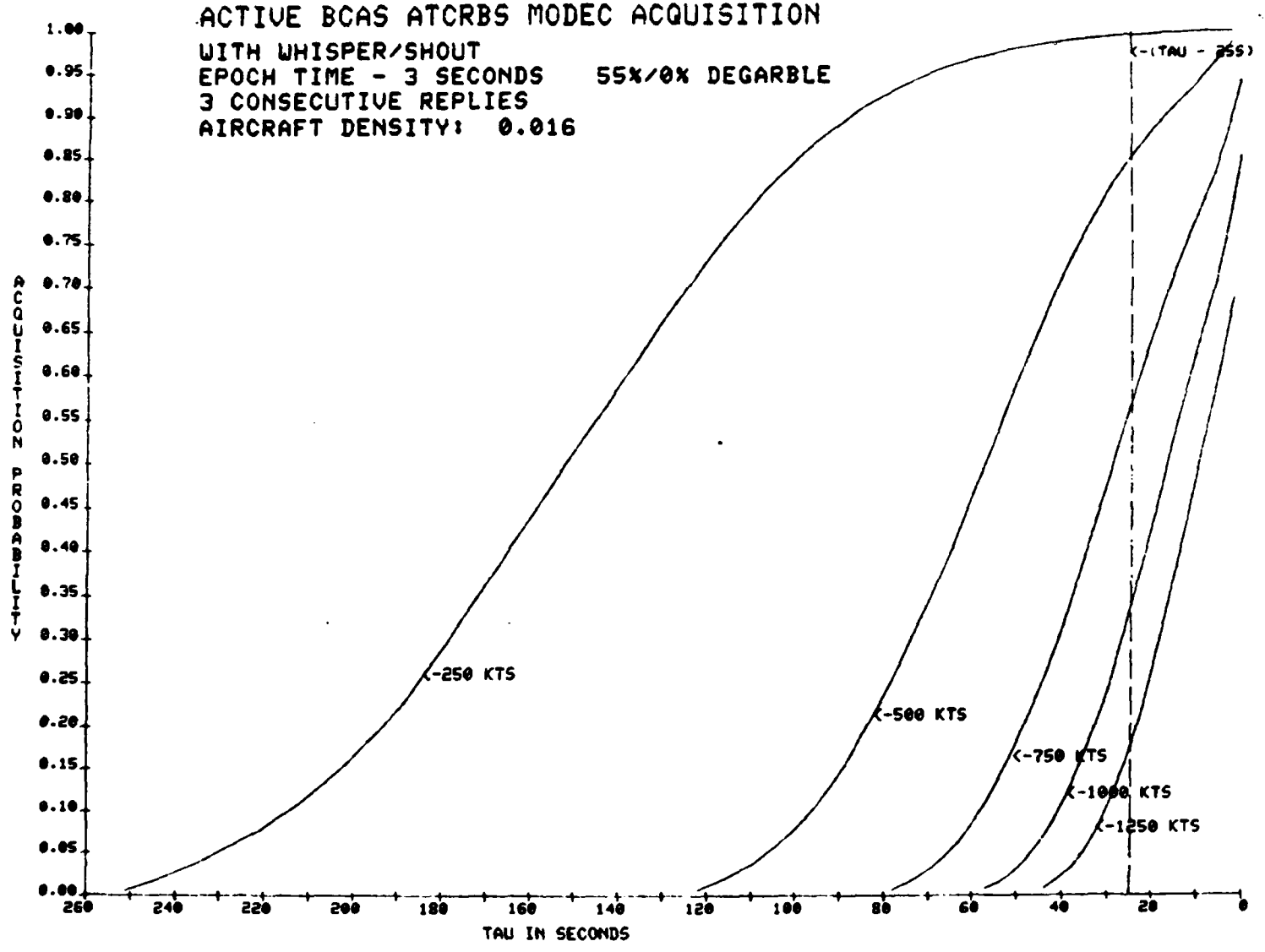

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
TAU IN SECONDS
R-(TAU - 35S)
R-250 KTS
R-500 KTS
R-750 KTS
R-1000 KTS
R-1250 KTS

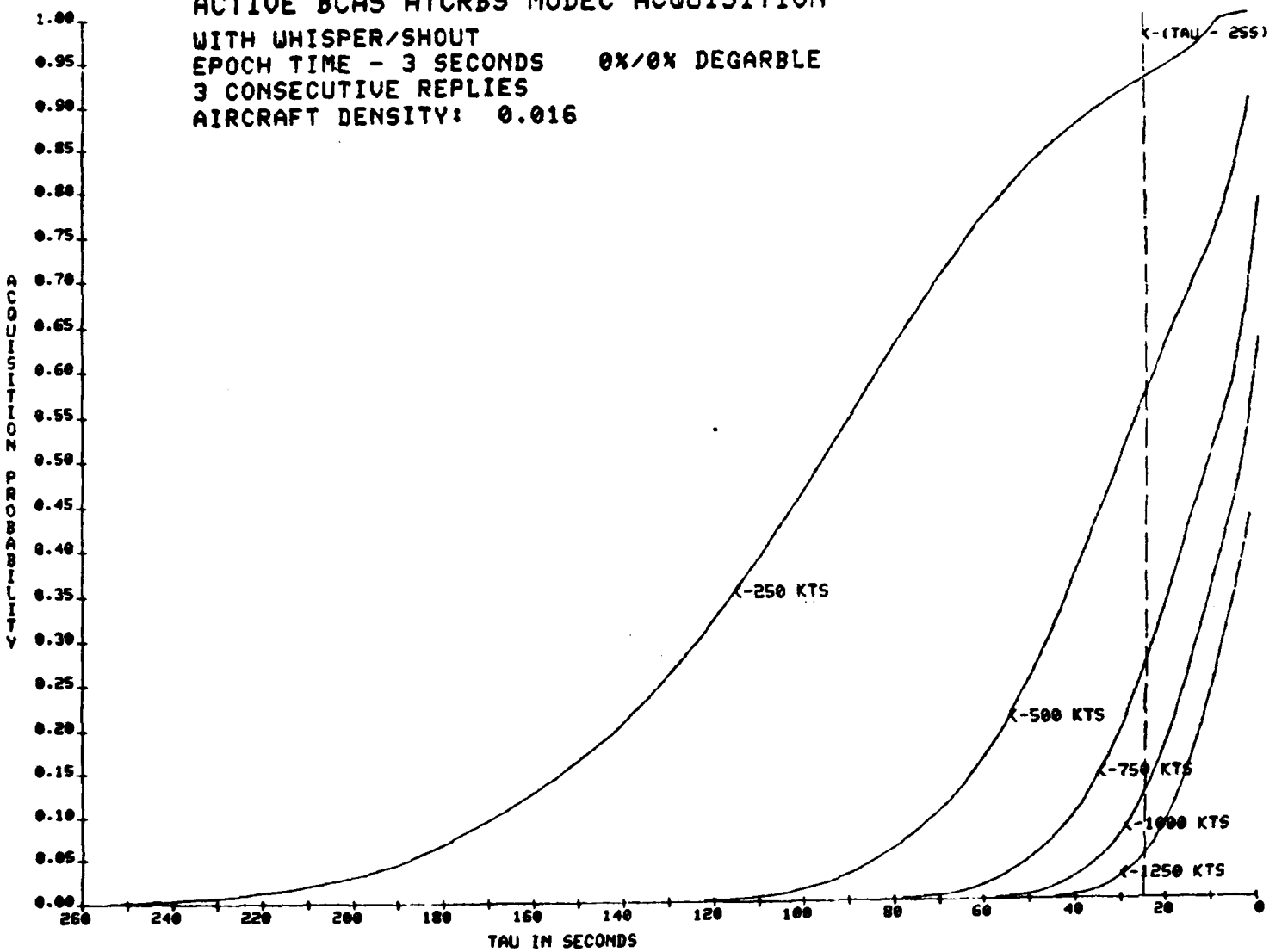

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS

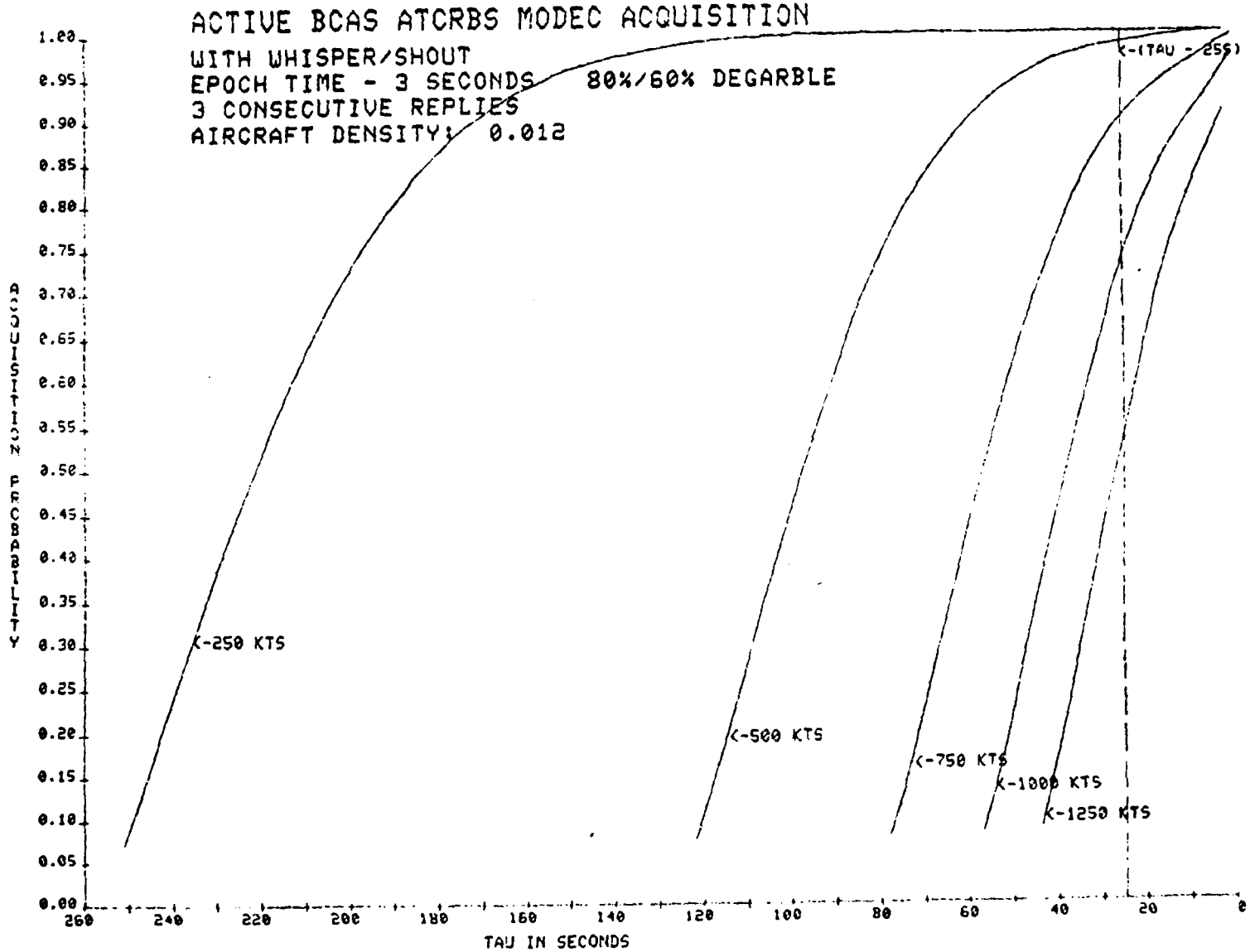

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU = 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 285)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
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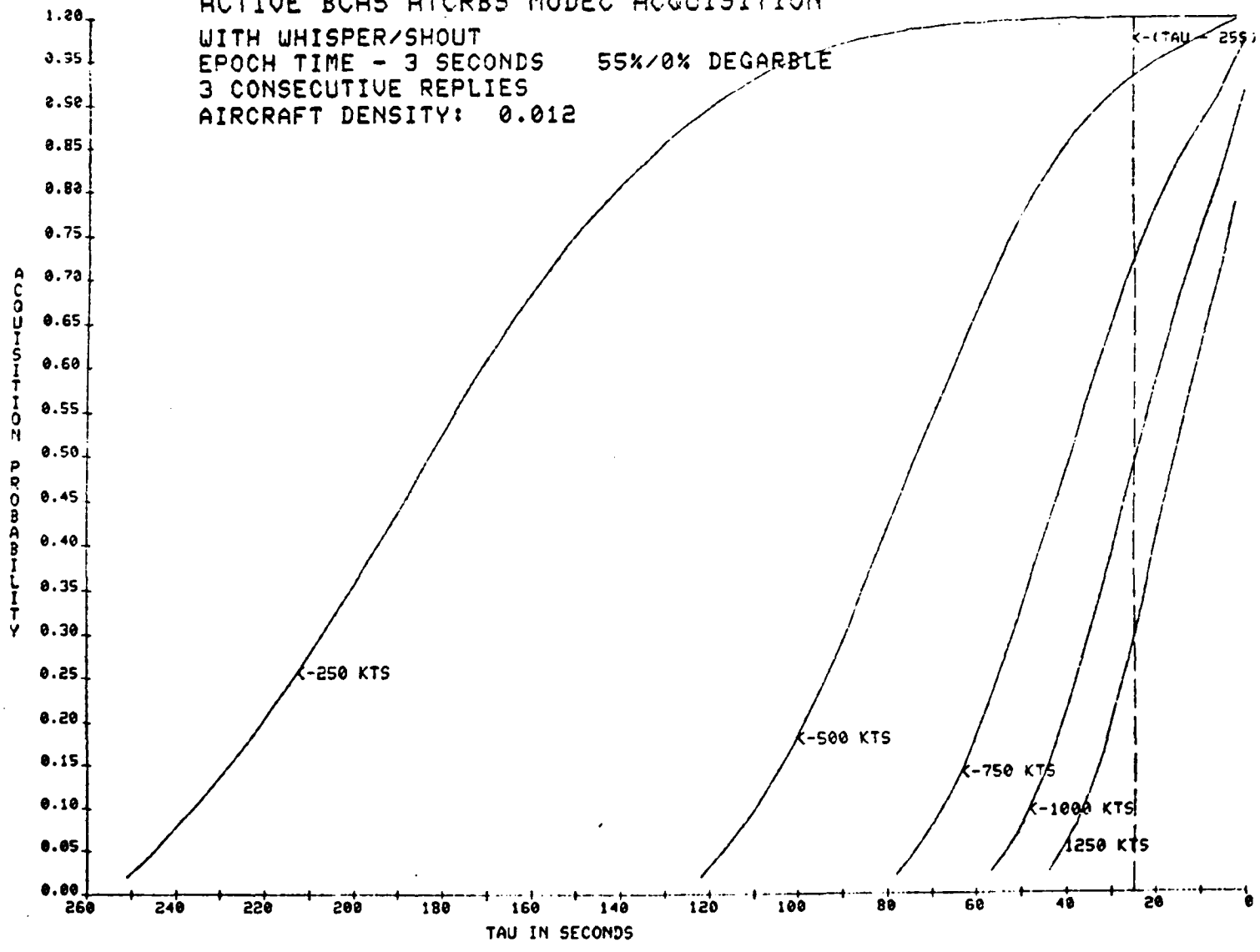
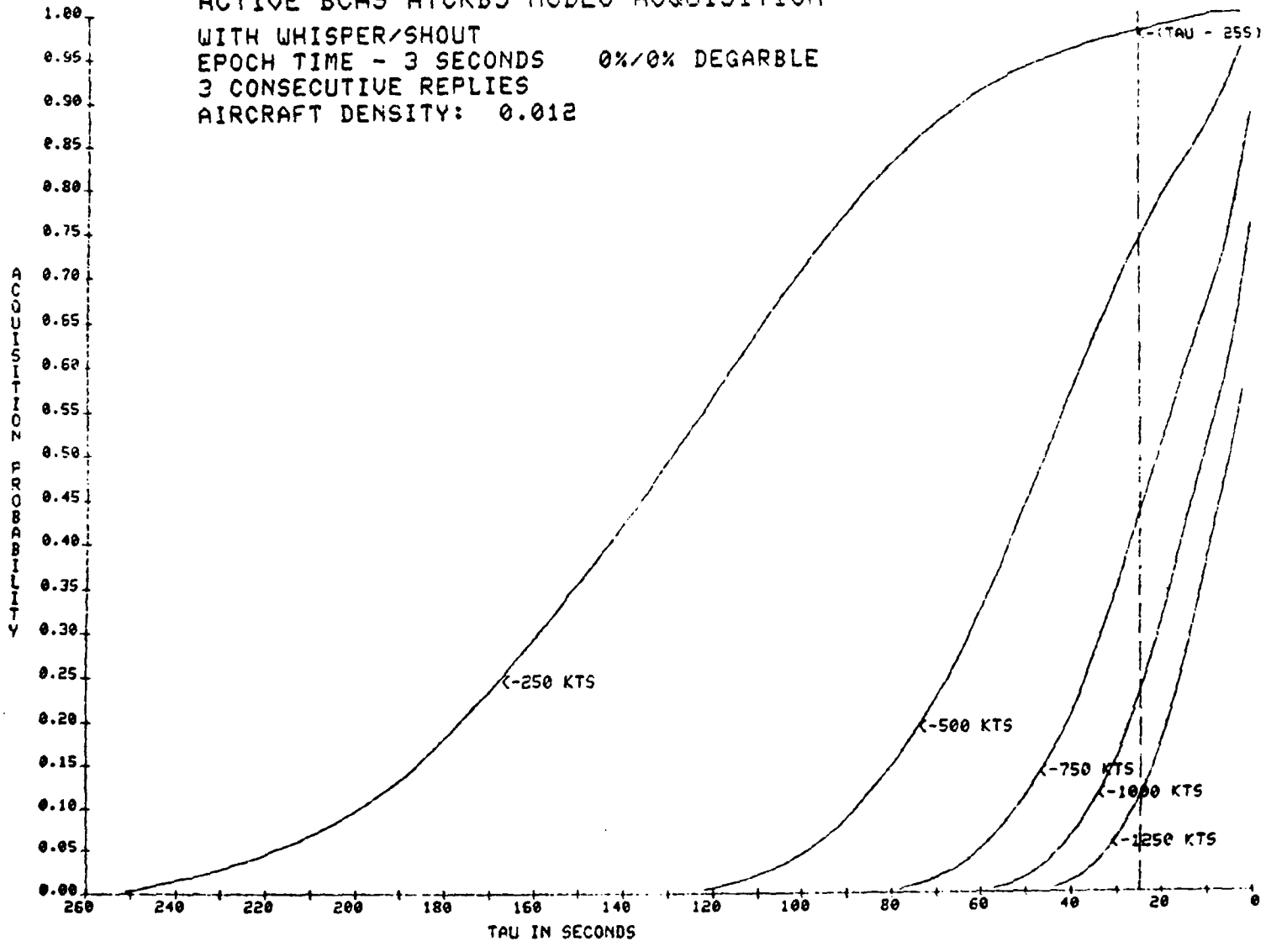
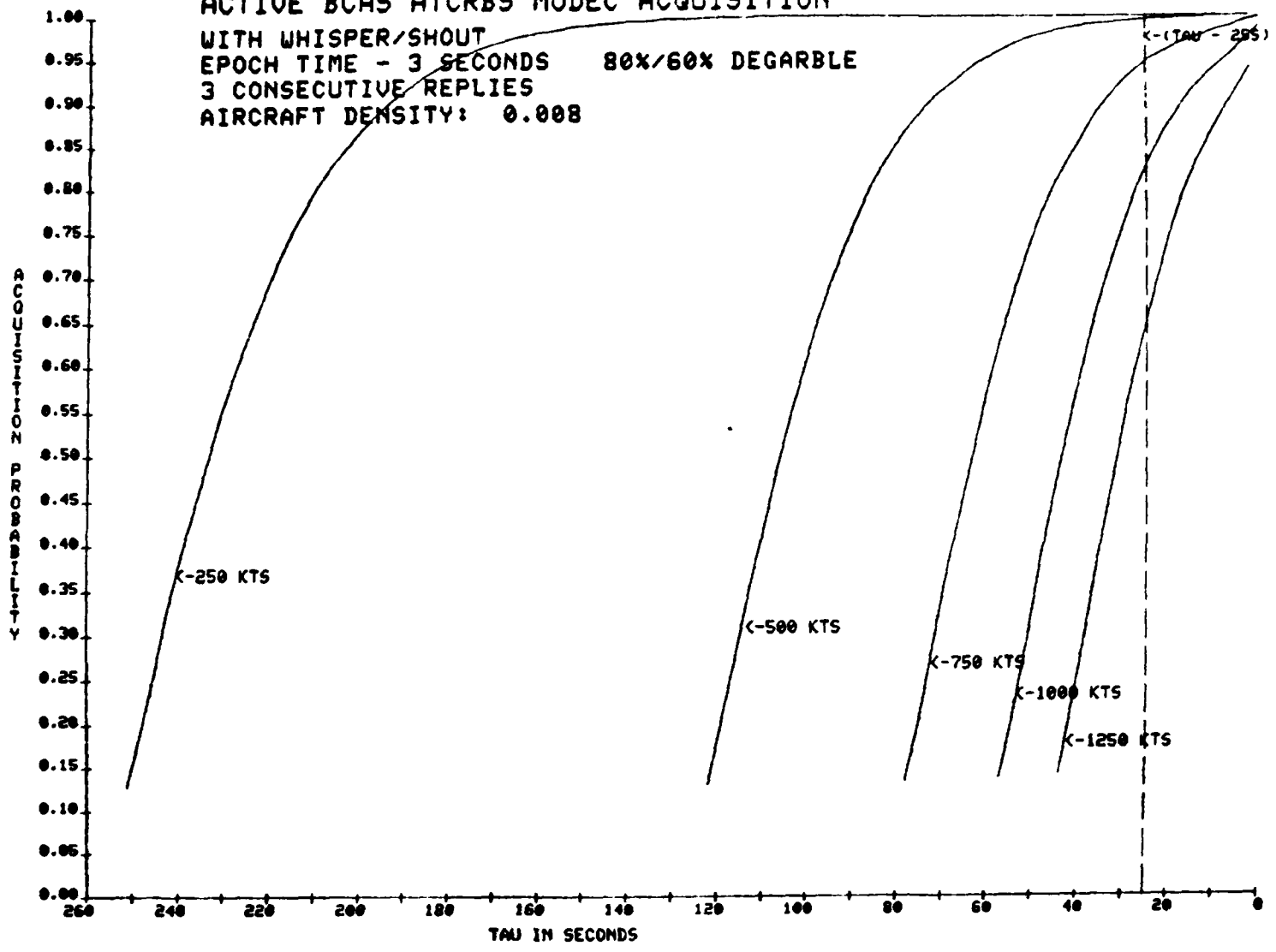
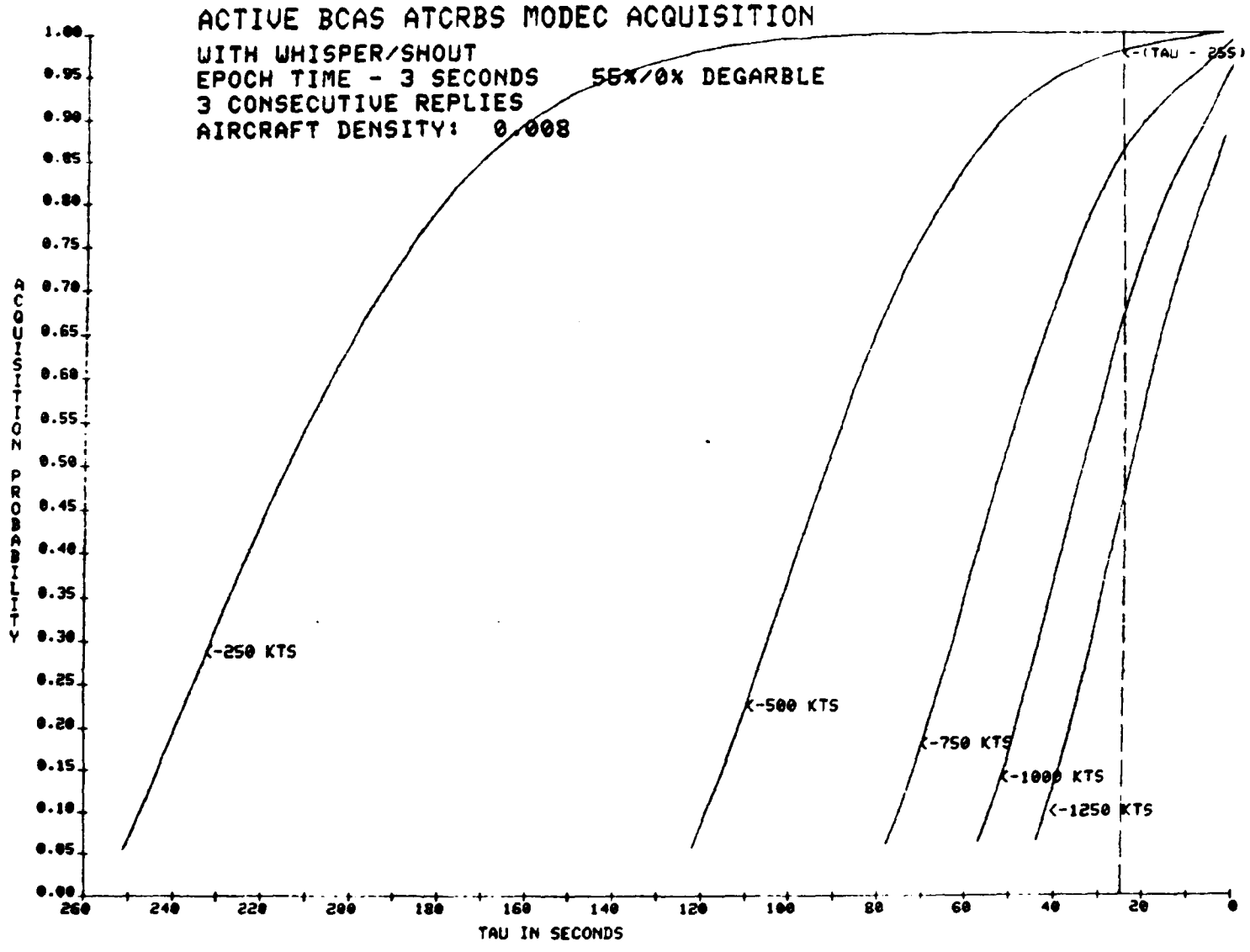
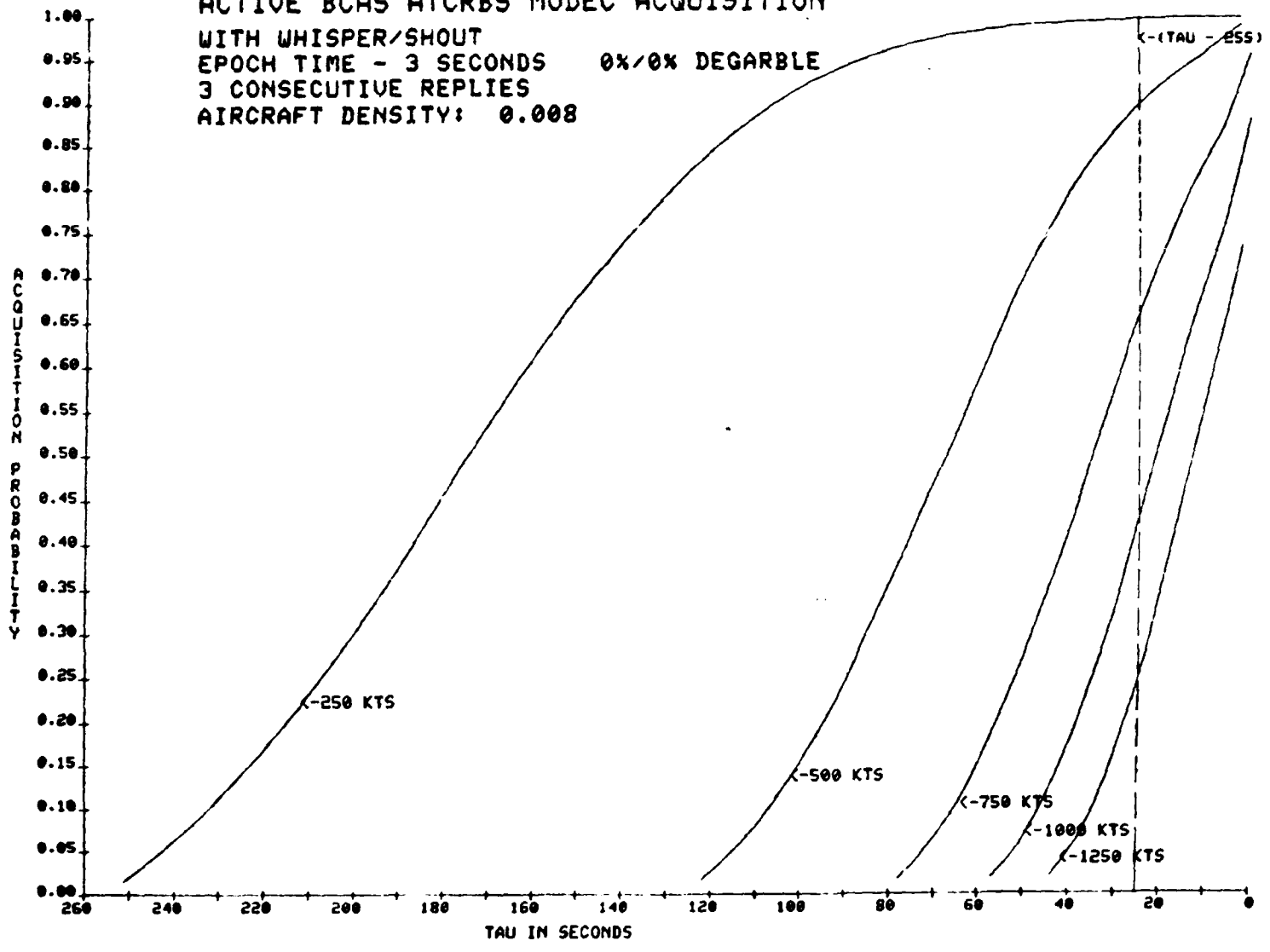
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 20S)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
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0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
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20
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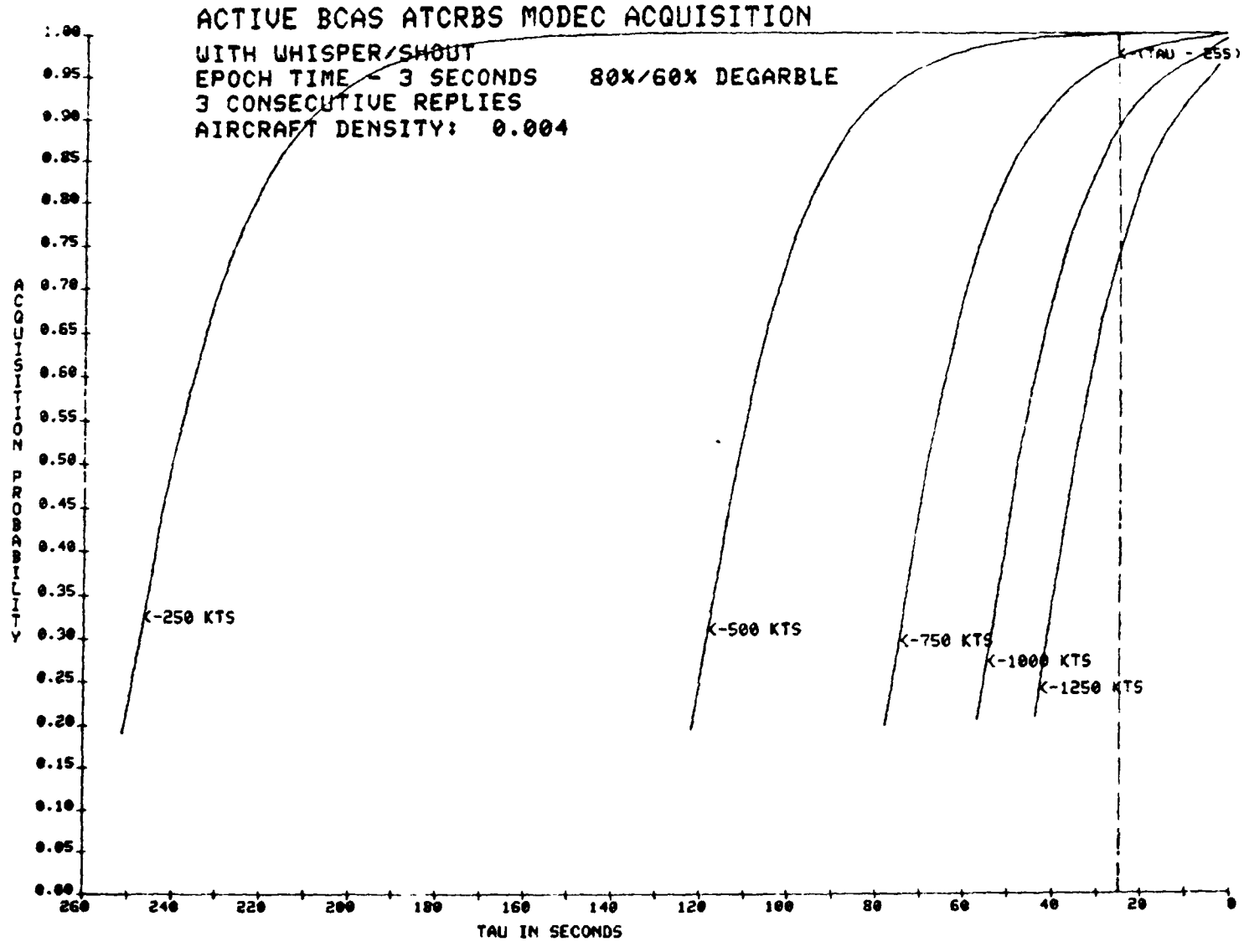
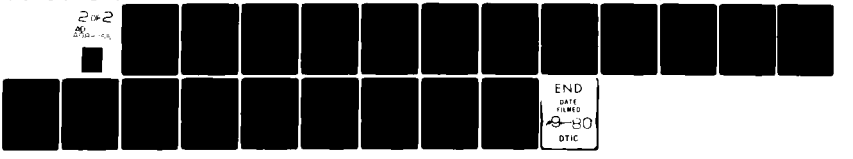
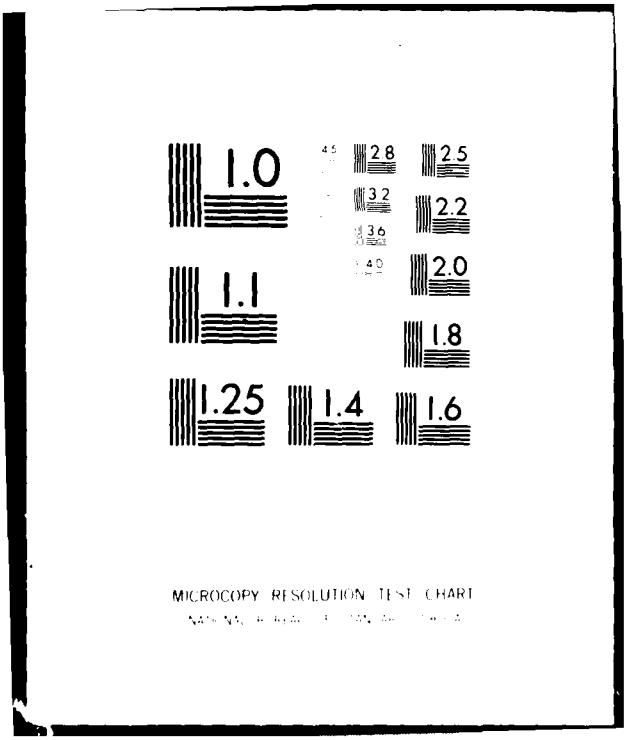
TAU IN SECONDS
<-(TAU - ESS)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS

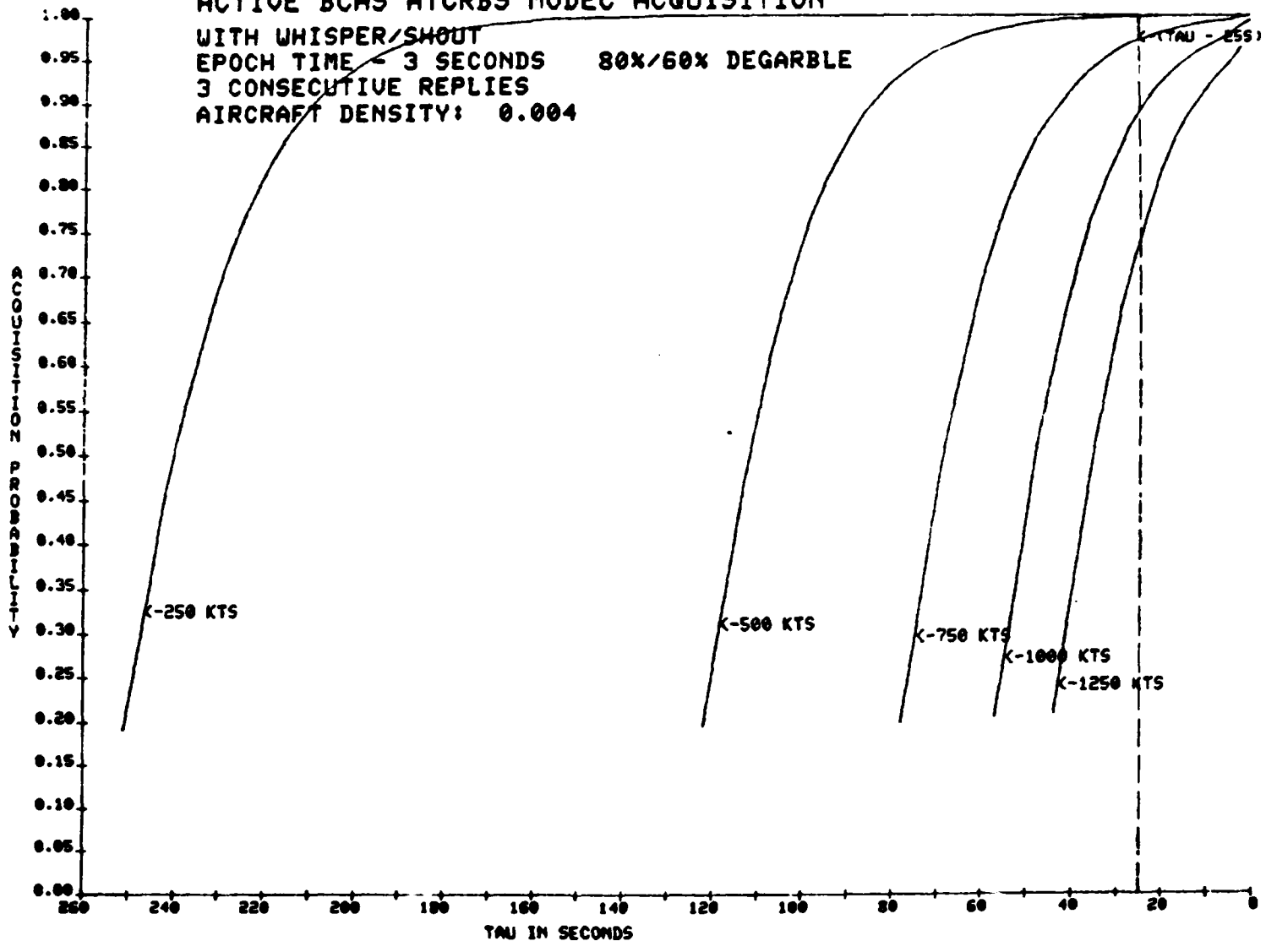

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME = 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-(TAU - 255)

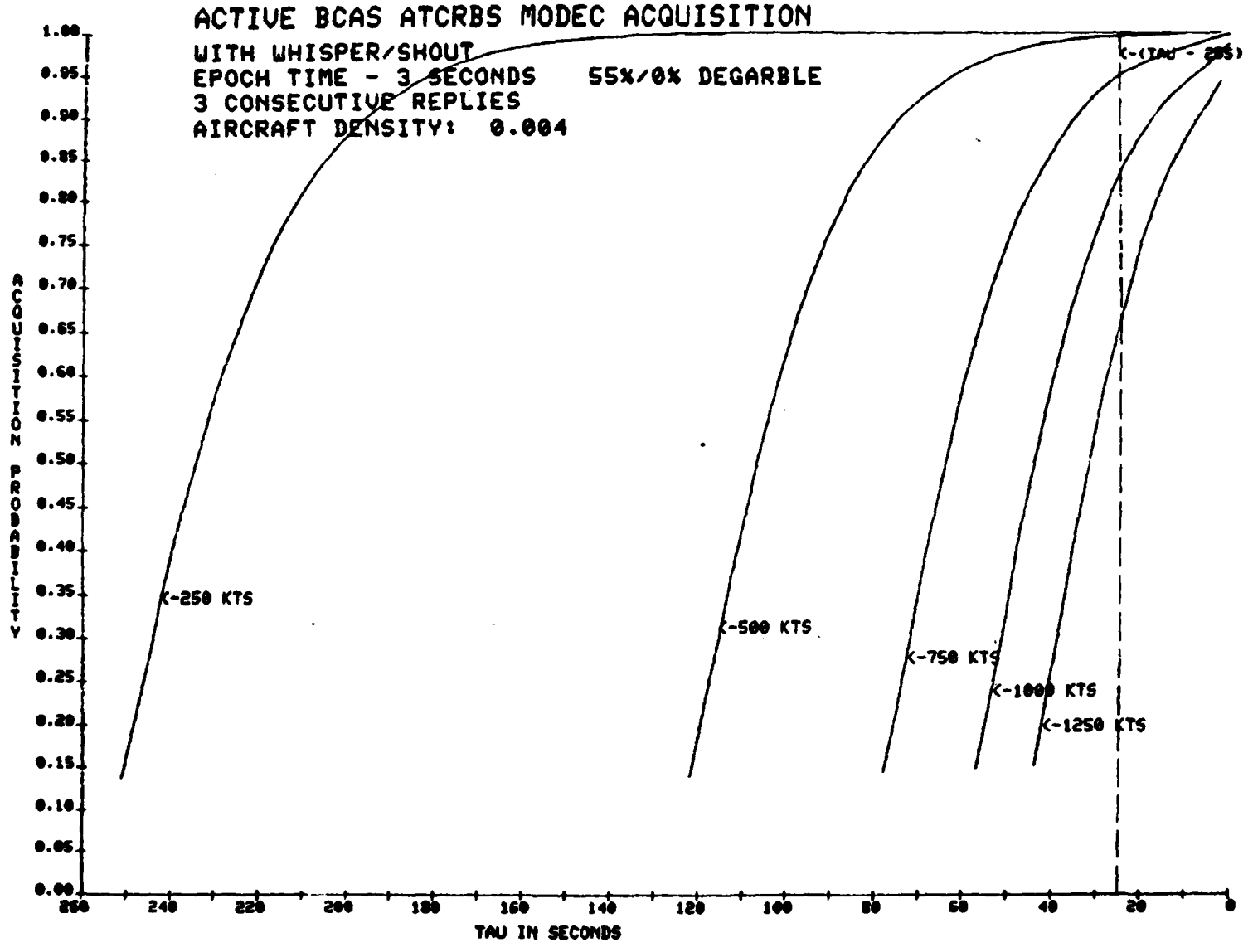
AD-A088 155 FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE--ETC F/G 1/2
THE EFFECT OF WHISPER/SHOUT ON ACTIVE BCAS PERFORMANCE,(U)
JUN 80 E J KOENKE, S BOCZENOWSKI

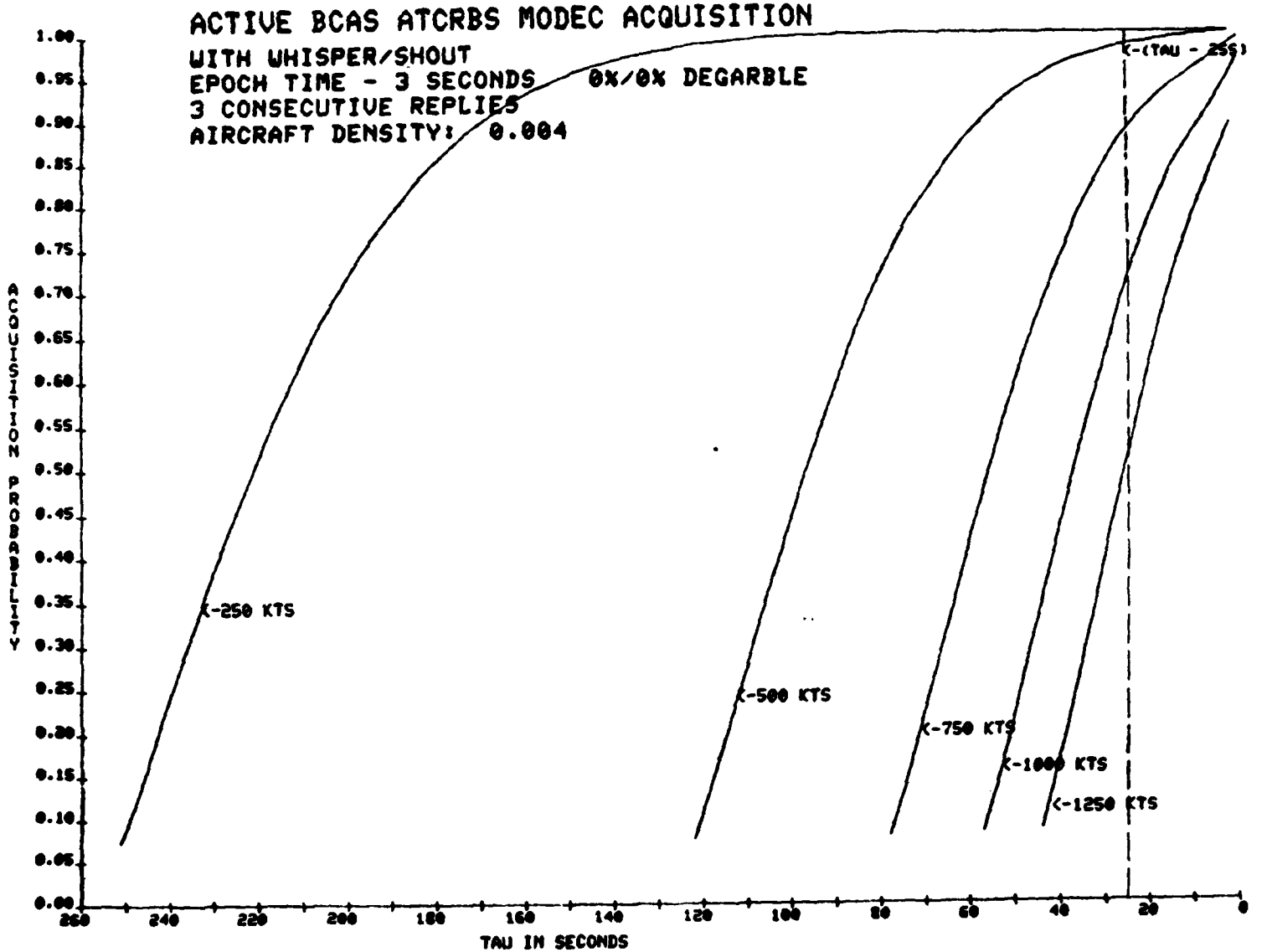
UNCLASSIFIED FAA-EM-80-5 NL

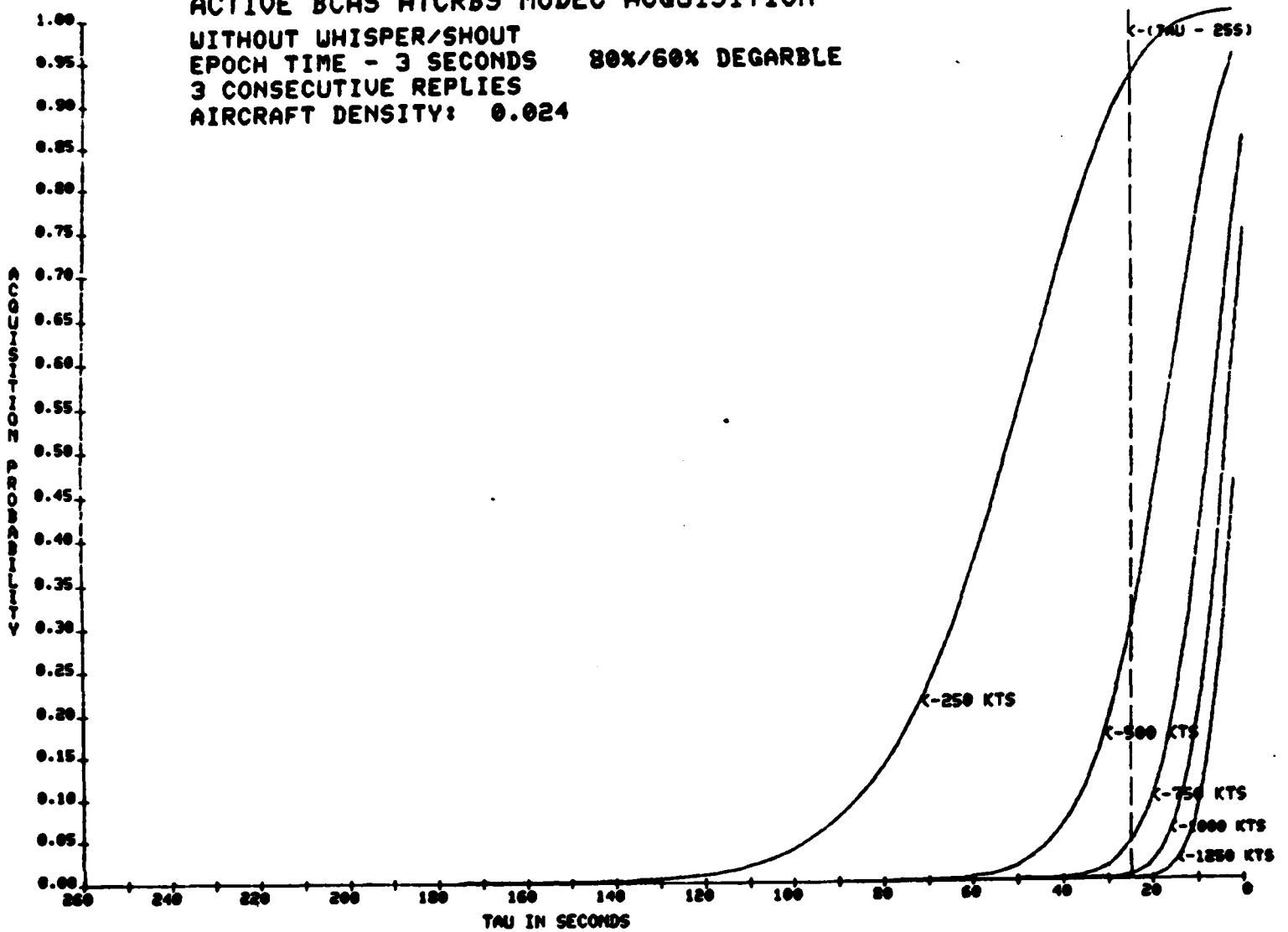


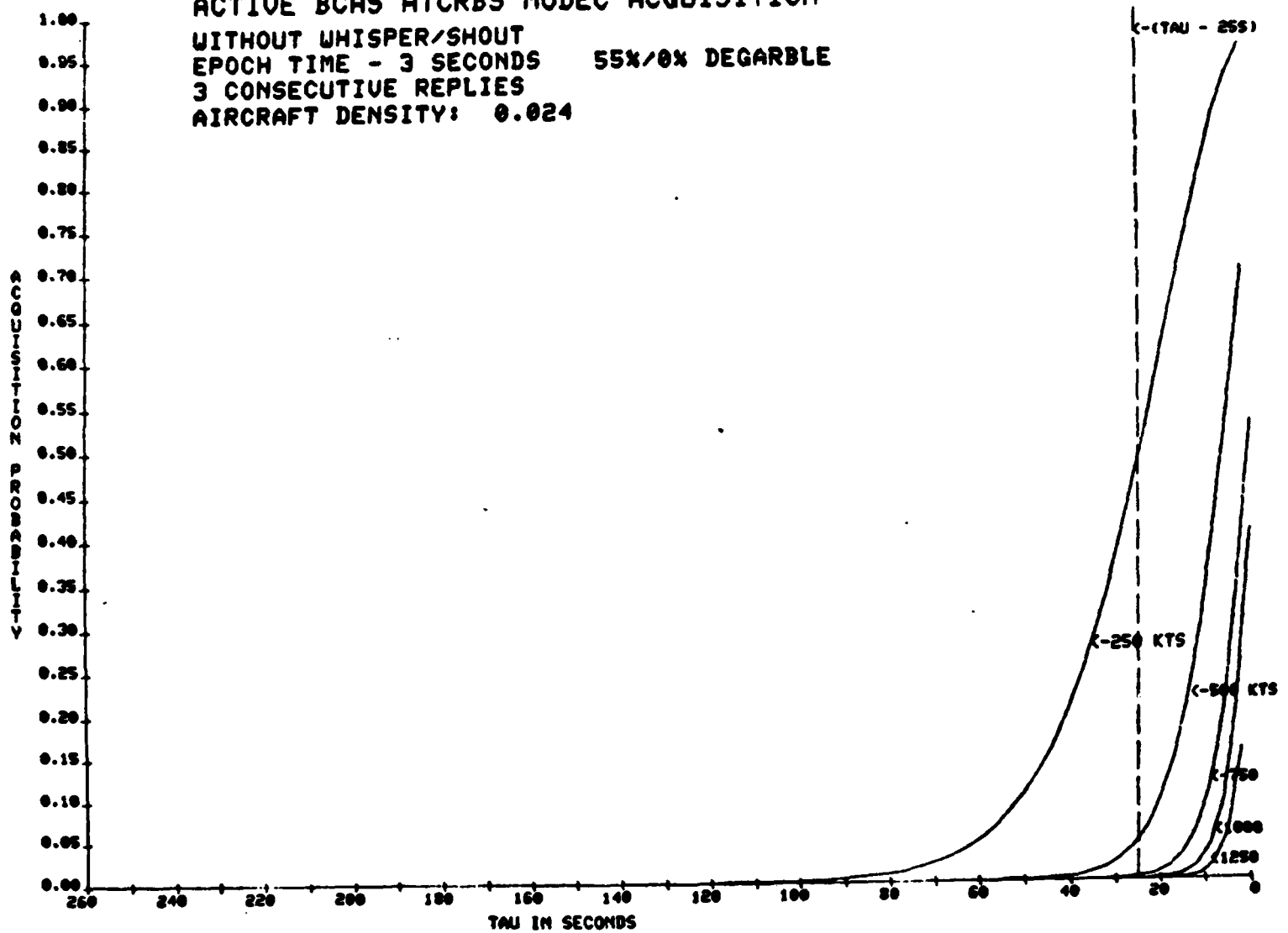

1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

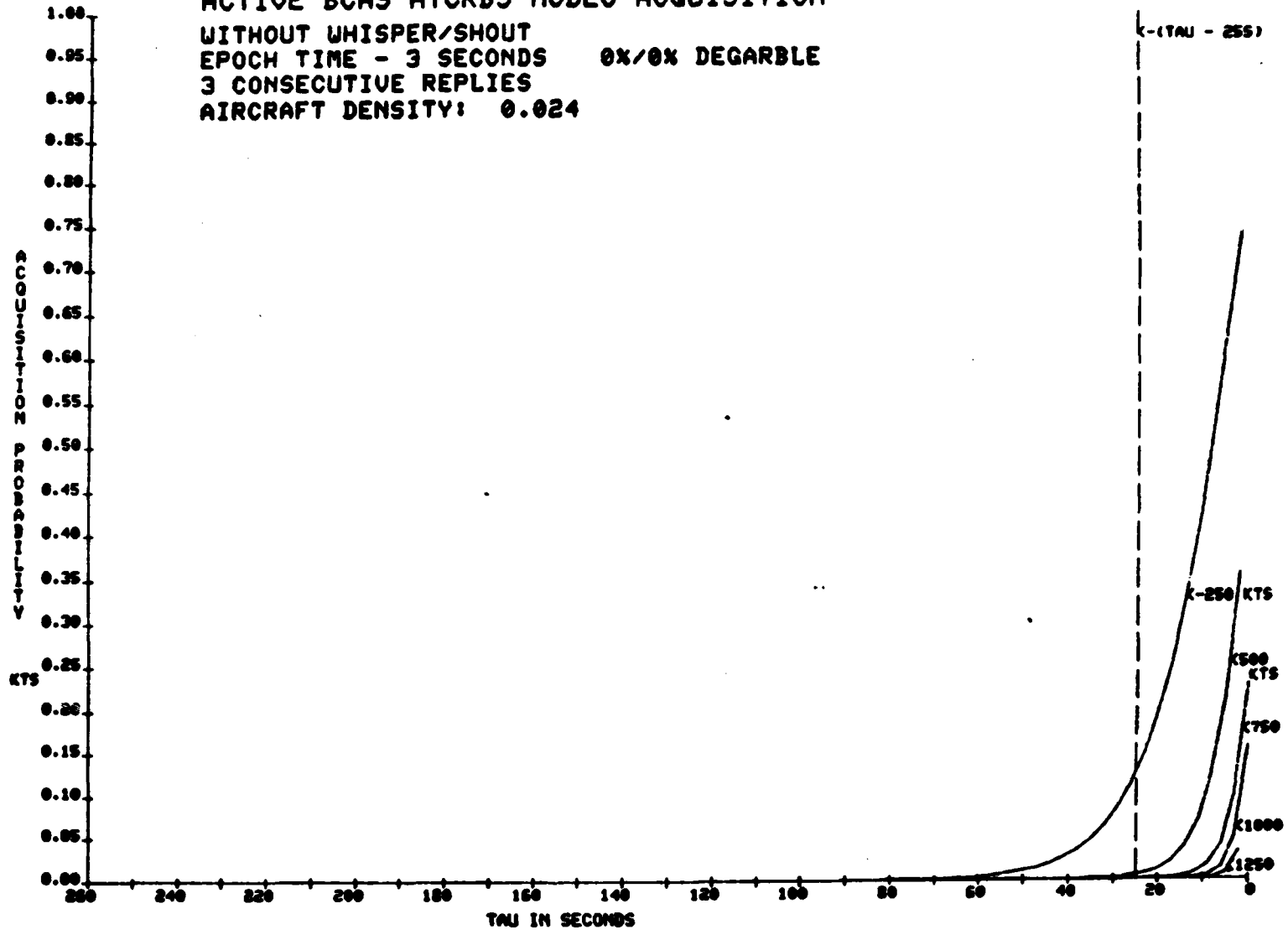

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME = 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITH WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 25s)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 255)
<-250 KTS
<-500 KTS
<-750
<1000
<1250


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.024
K-(TAU - 255)
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
K-250 KTS
K500 KTS
K750
K1000
K1250
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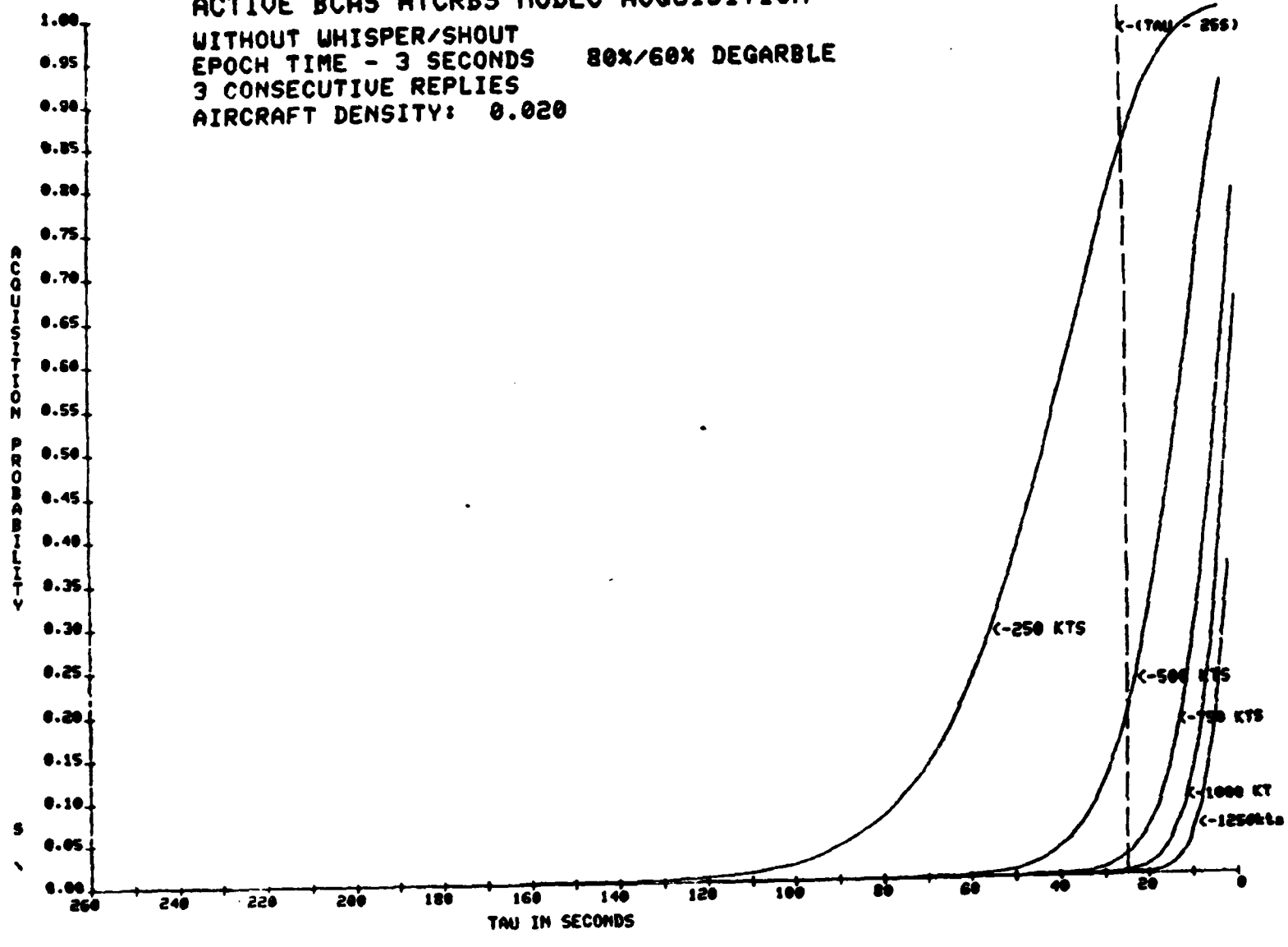
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
TAU IN SECONDS
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
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240
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200
180
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140
120
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60
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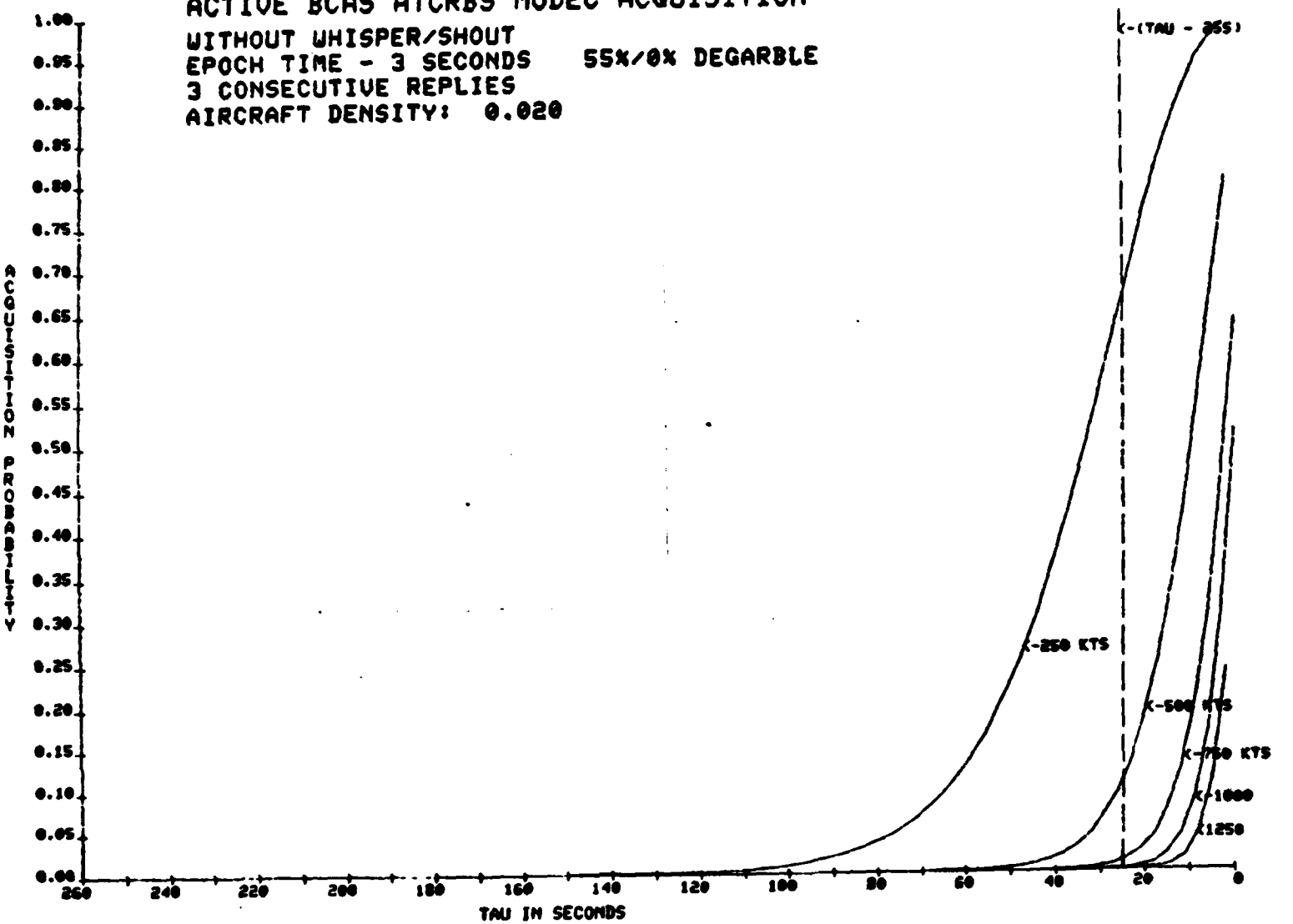
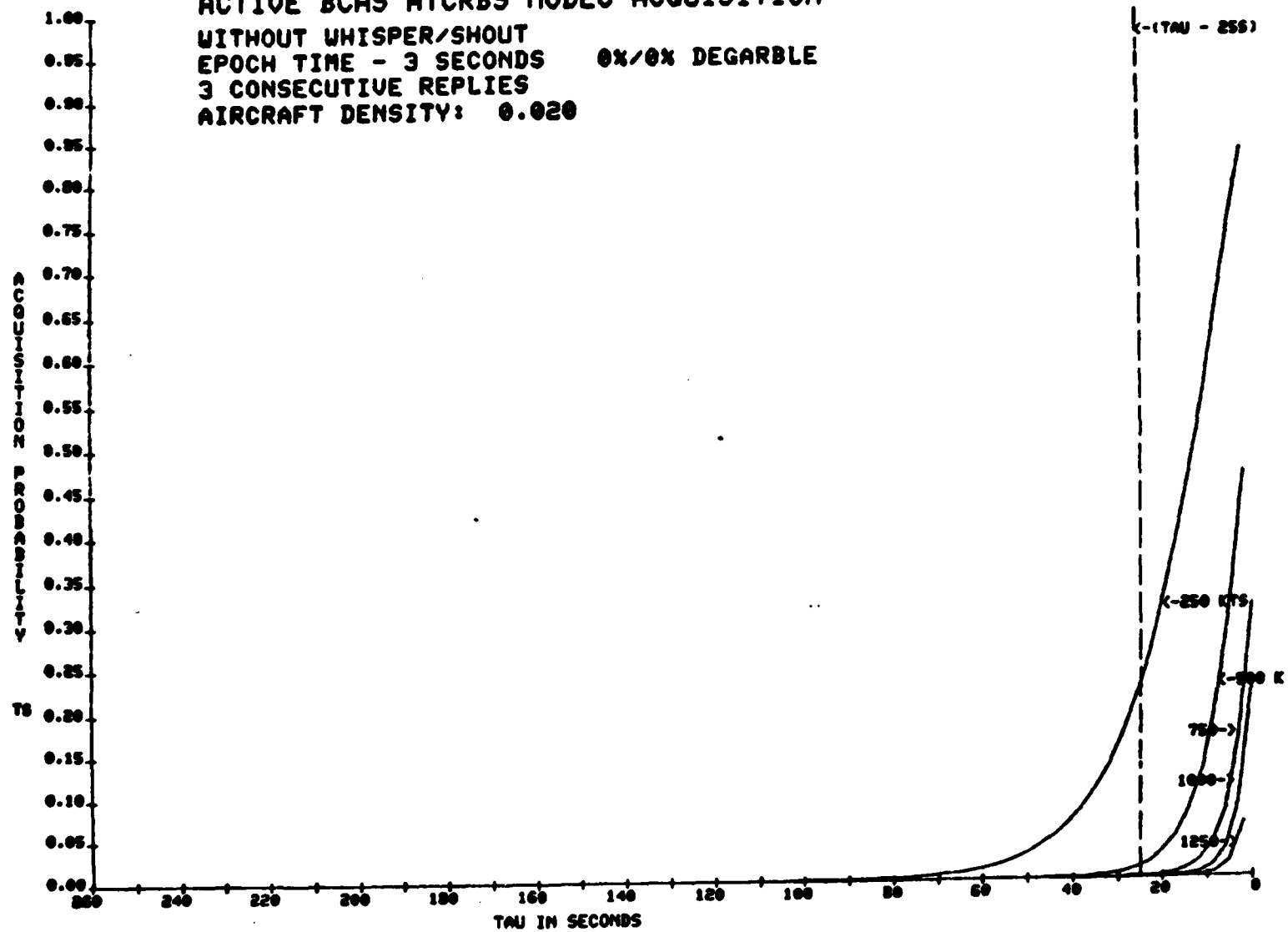
20
0
(-250 KTS
(-1000 KT


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000
K1250


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.020
ACQUISITION PROBABILITY
TS
TAU IN SECONDS
<-(TAU - 25S)
<-250 KTS
750->
1000->
1250->
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
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0.55
0.50
0.45
0.40
0.35
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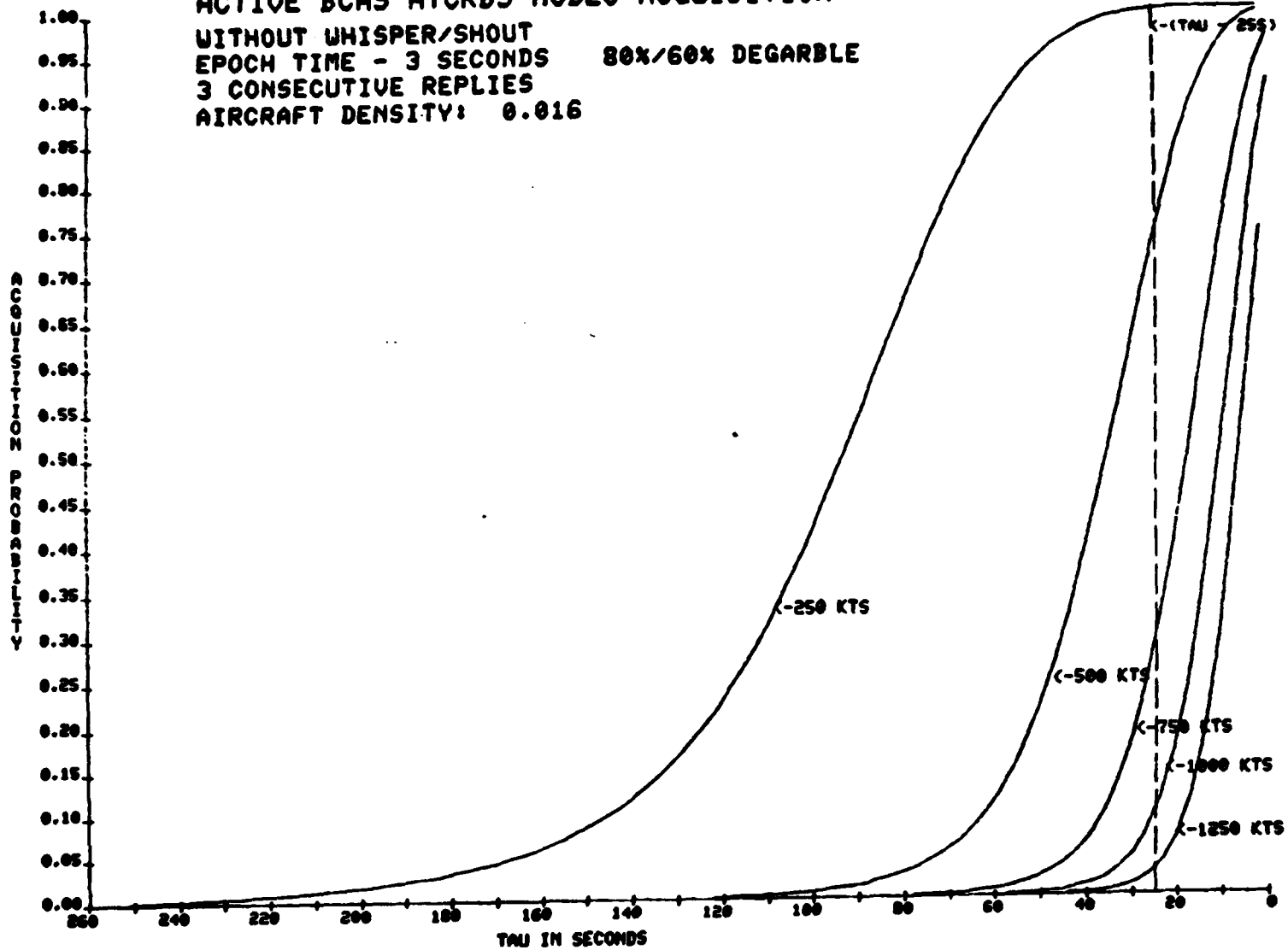
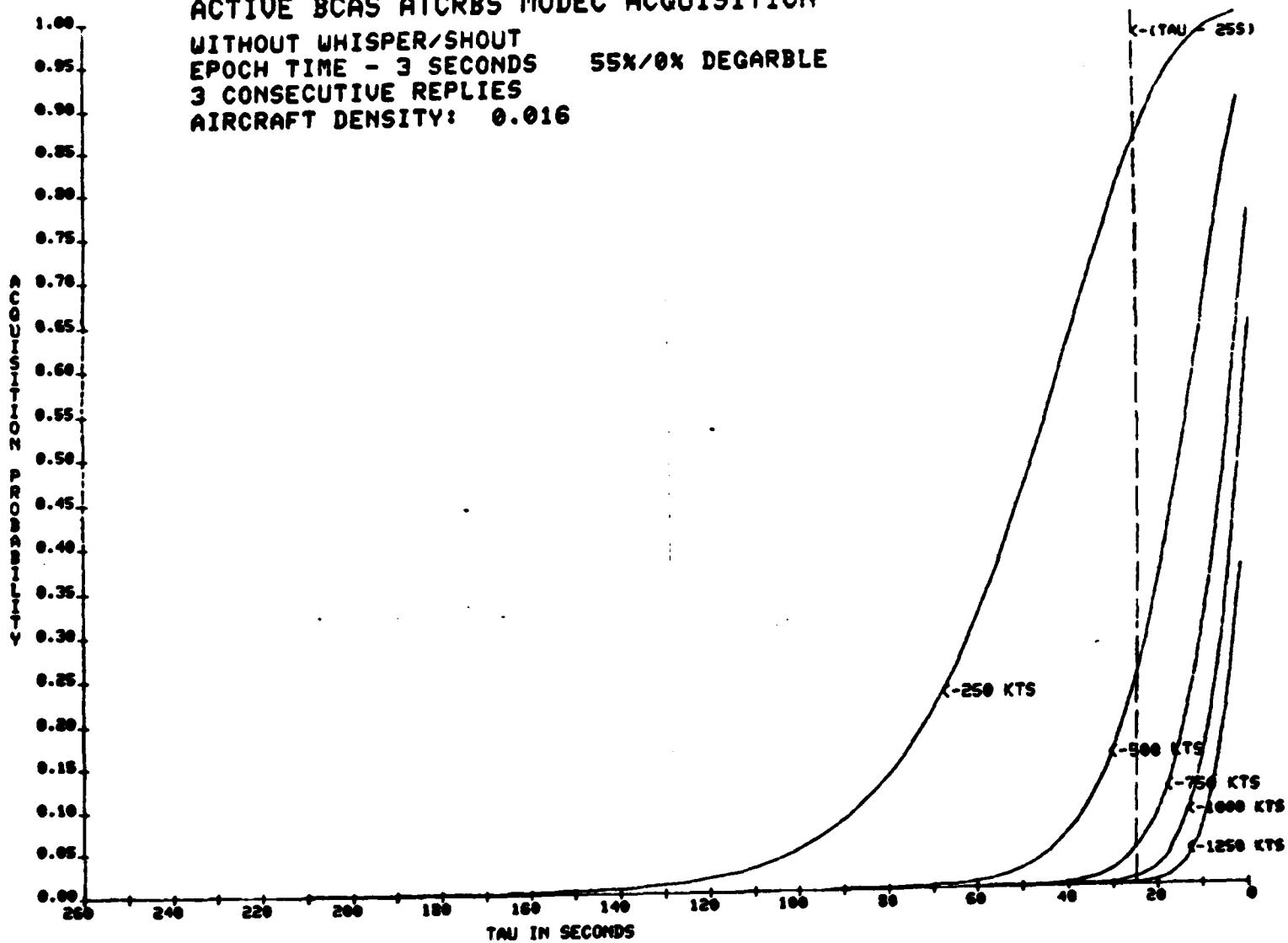
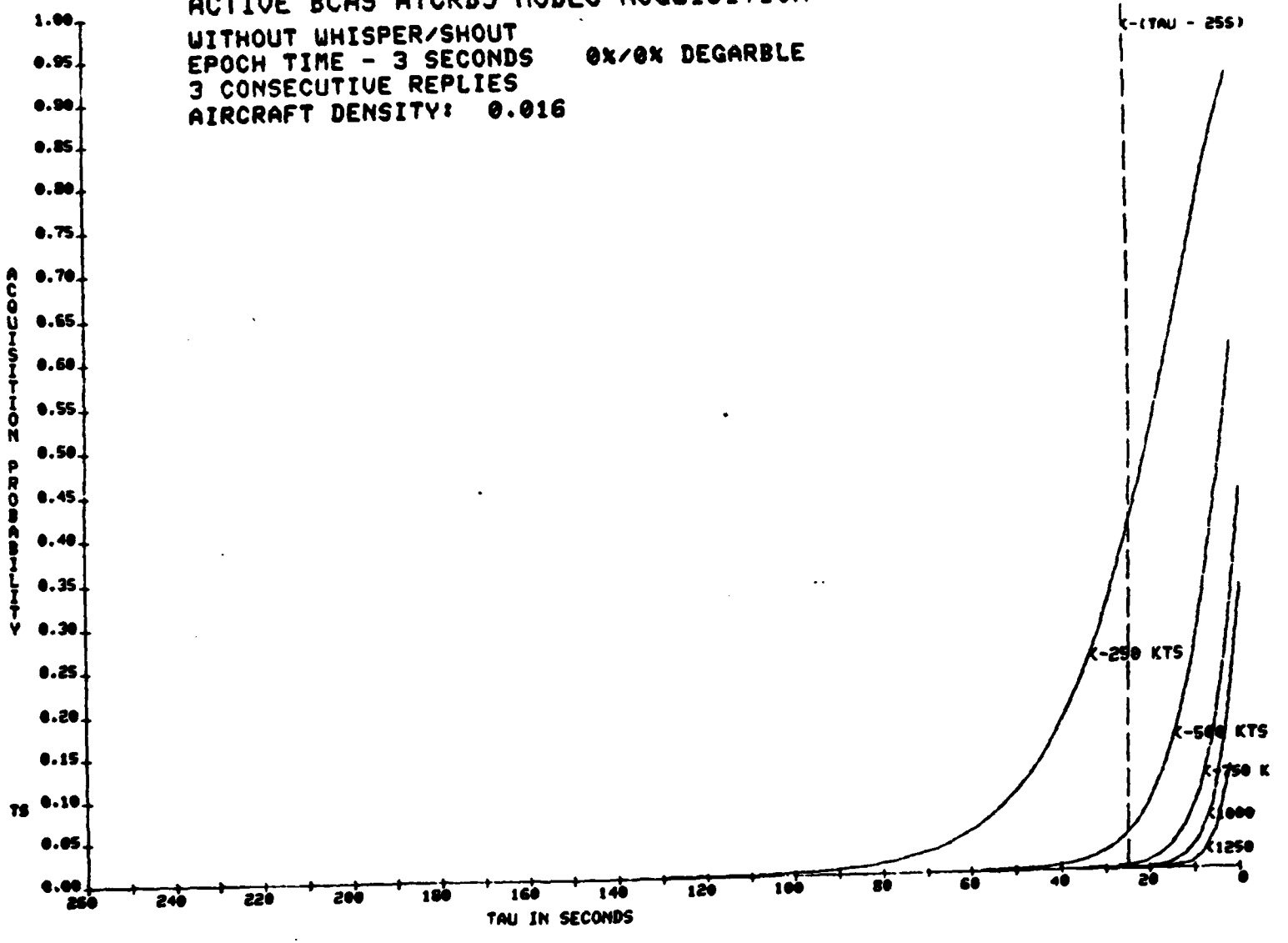

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 25)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU = 255)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.016
ACQUISITION PROBABILITY
TS
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 K
K1000
K1250
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
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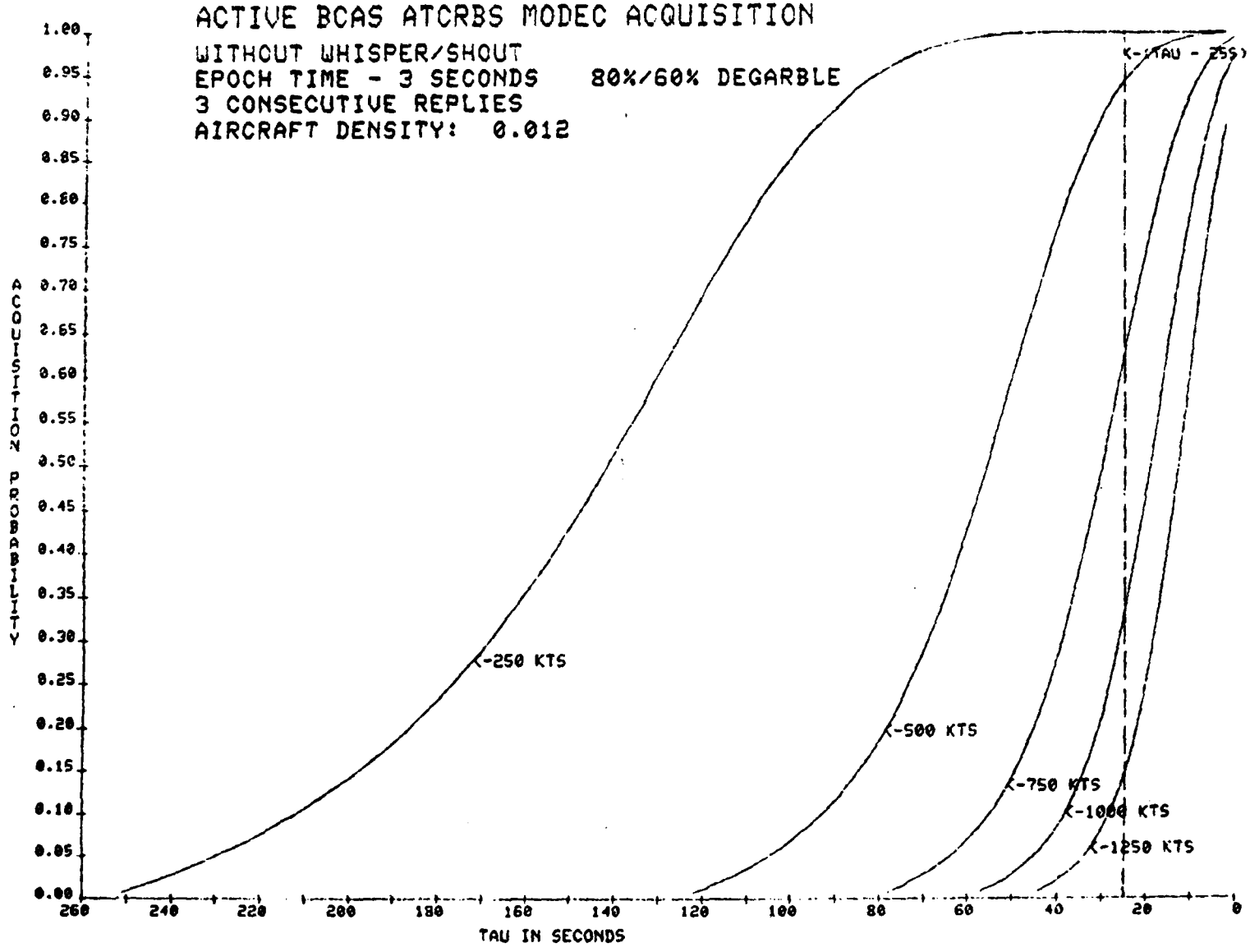
ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
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0.10
0.05
0.00
260
240
220
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120
100
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60
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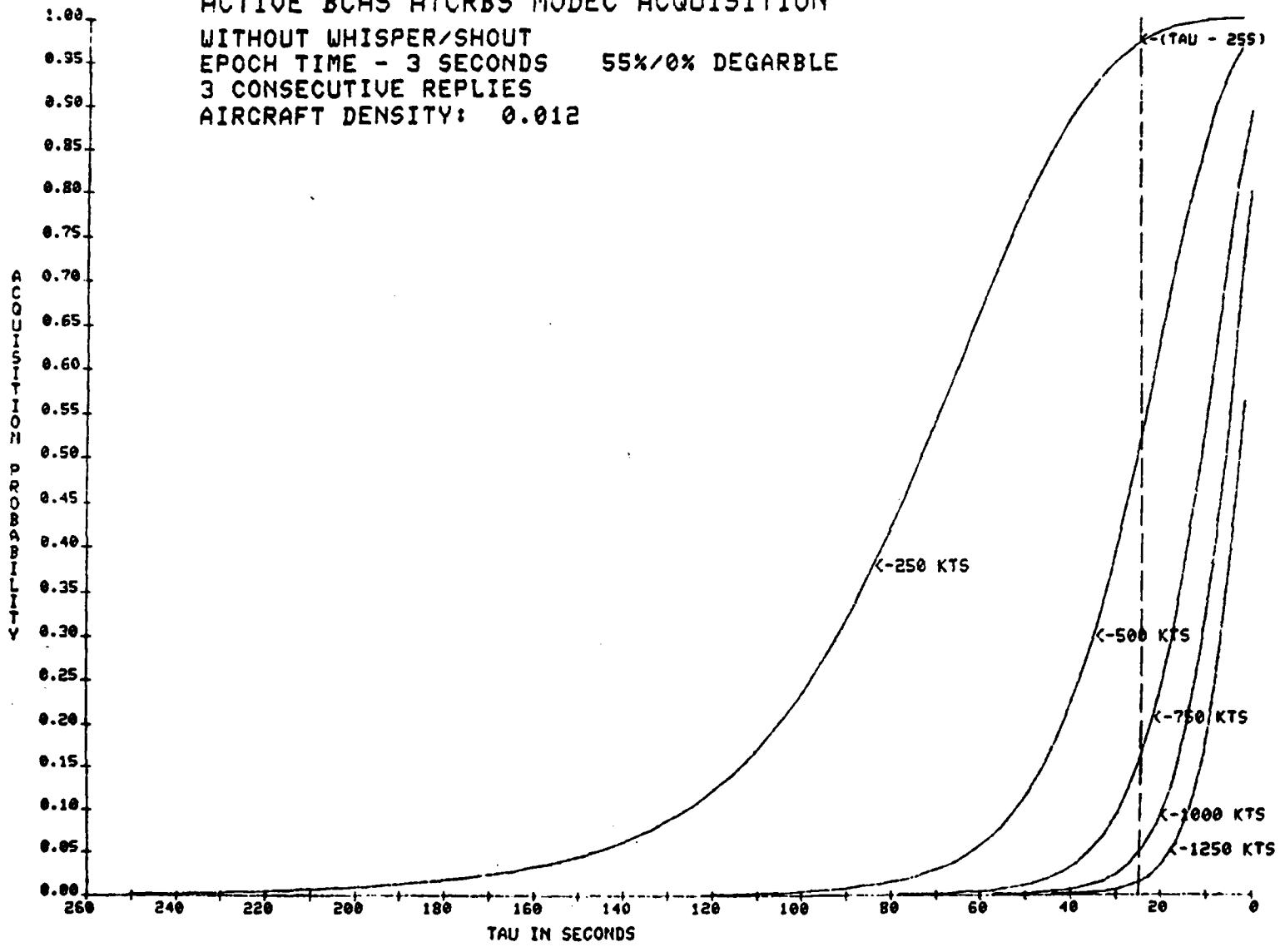
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
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260
240
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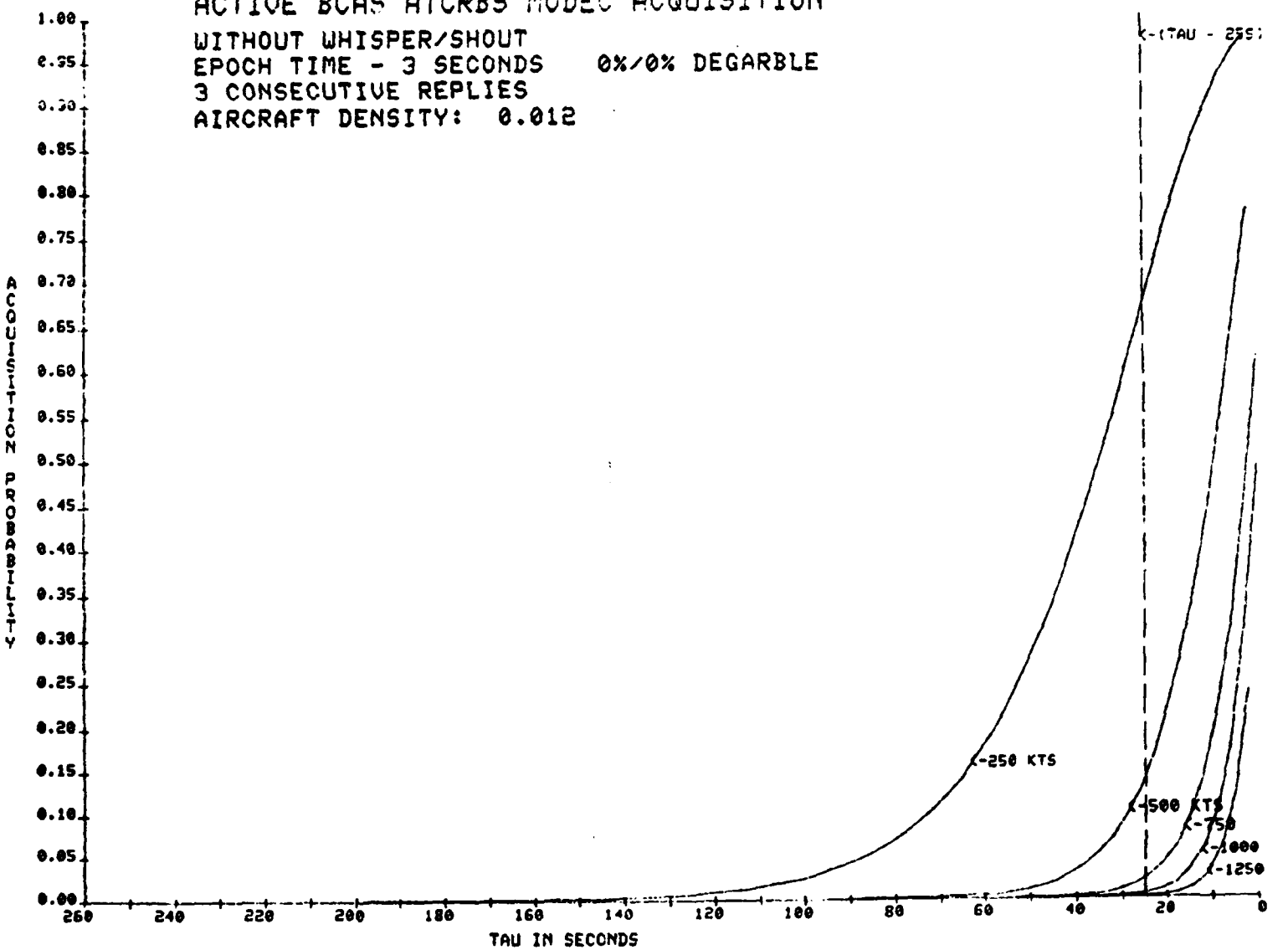
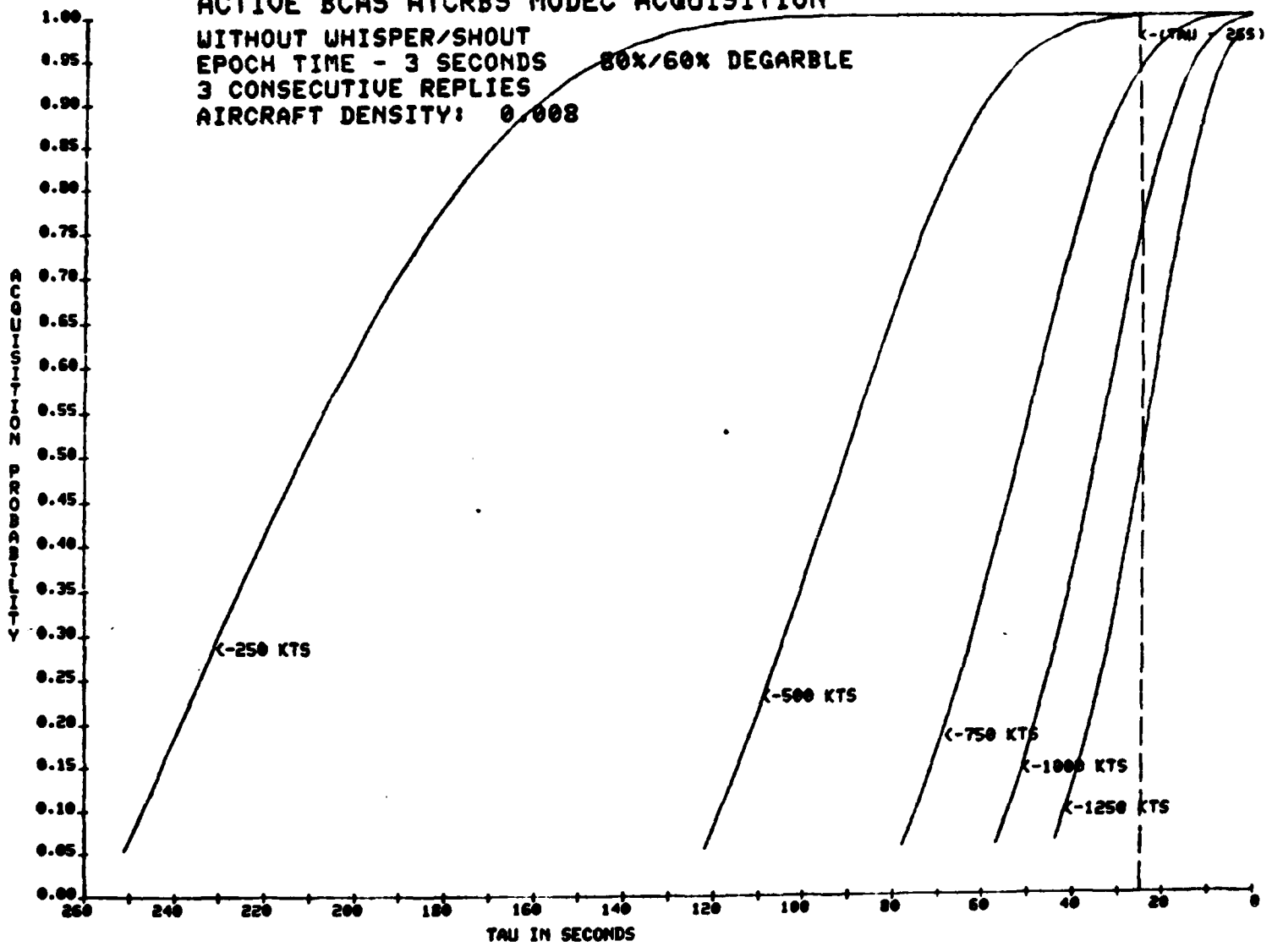
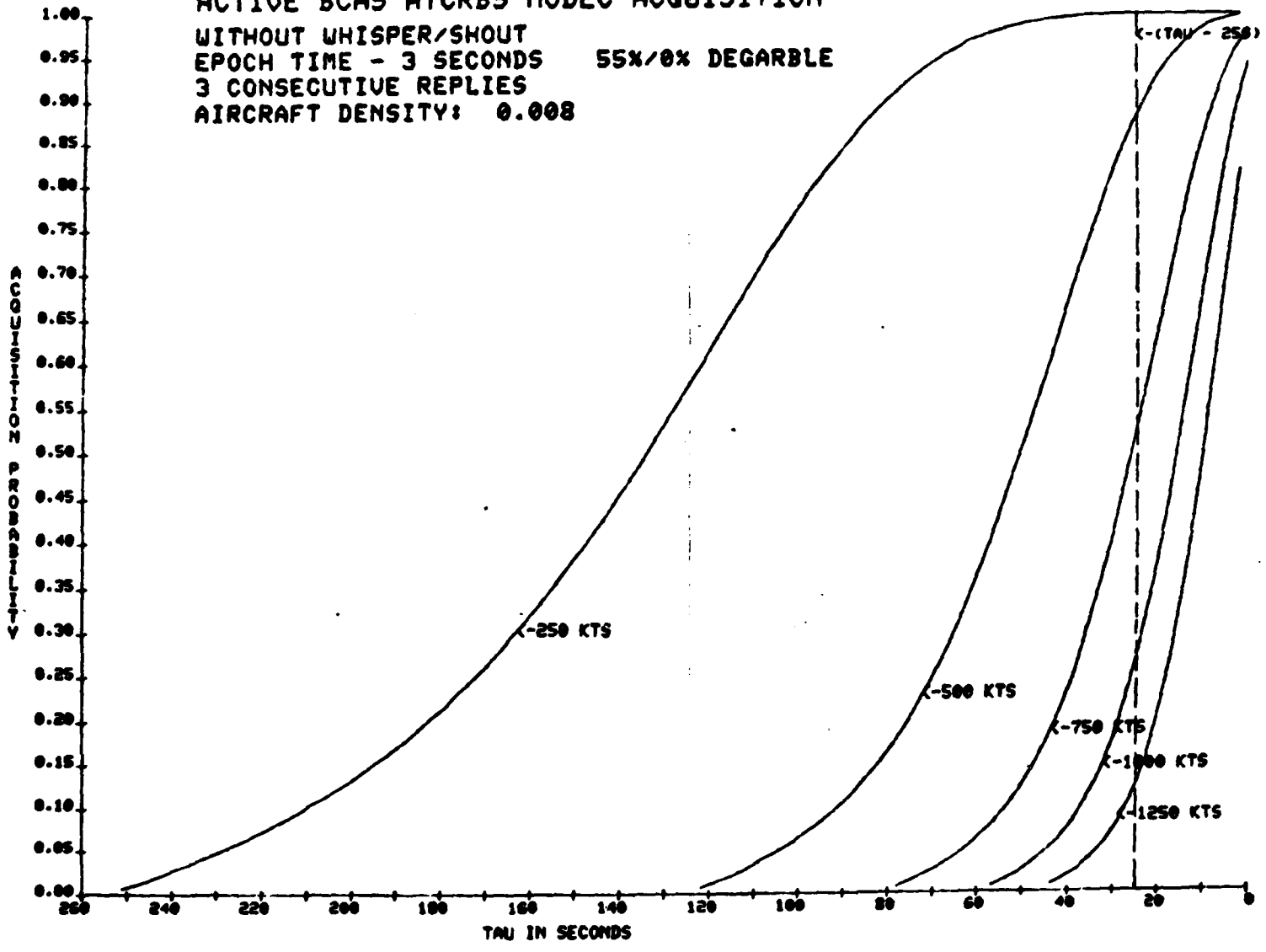
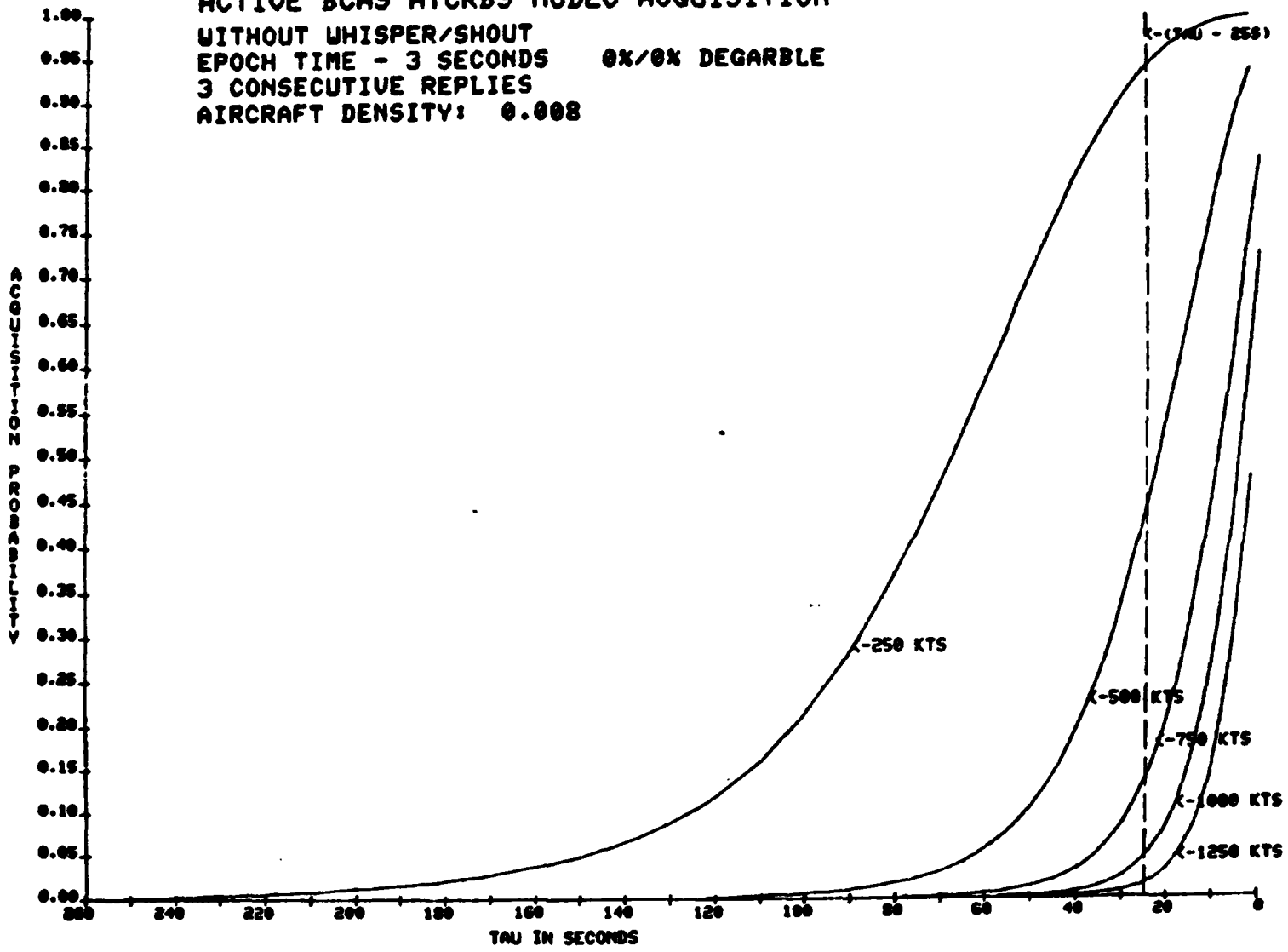
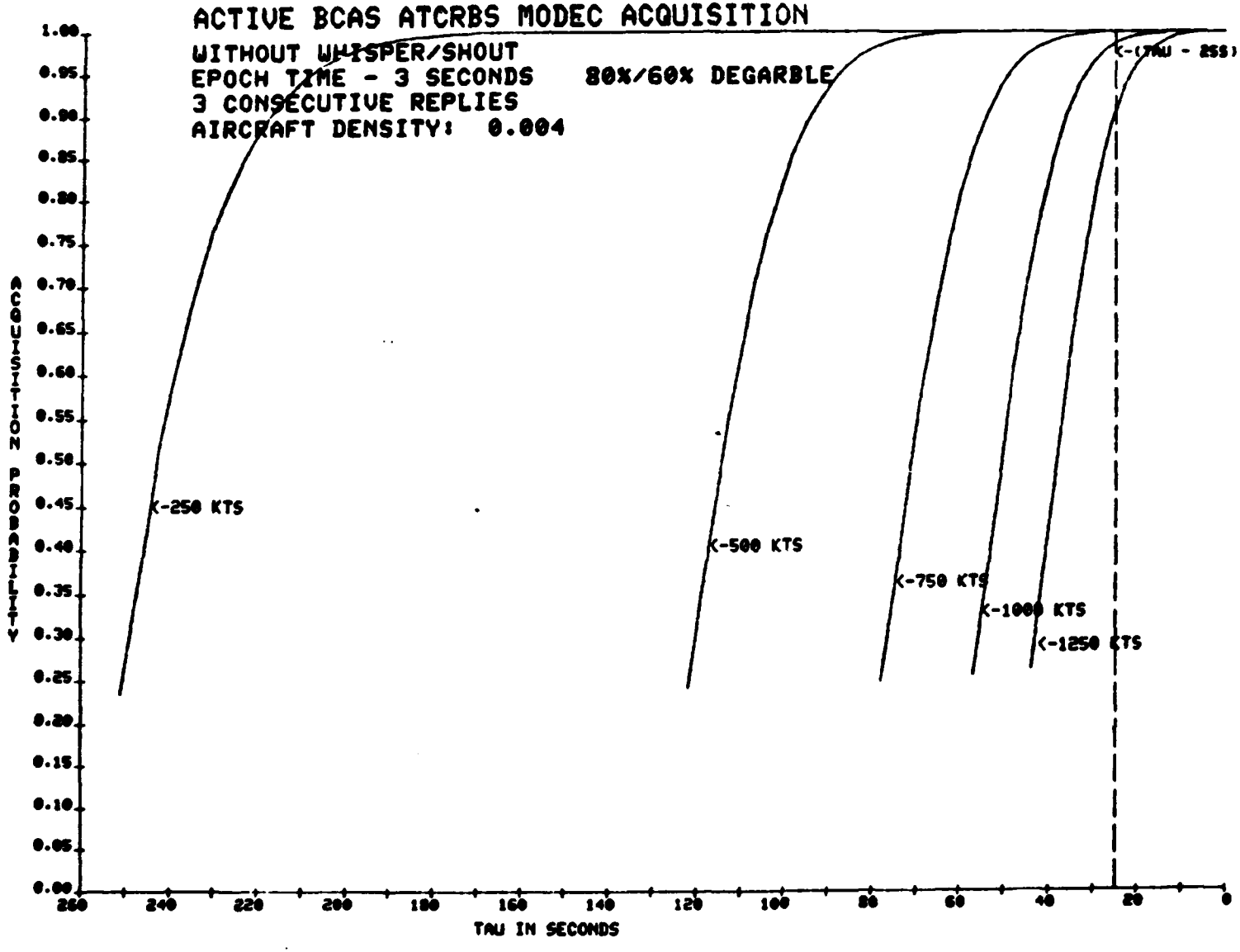
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K=(TAU - 255)
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS

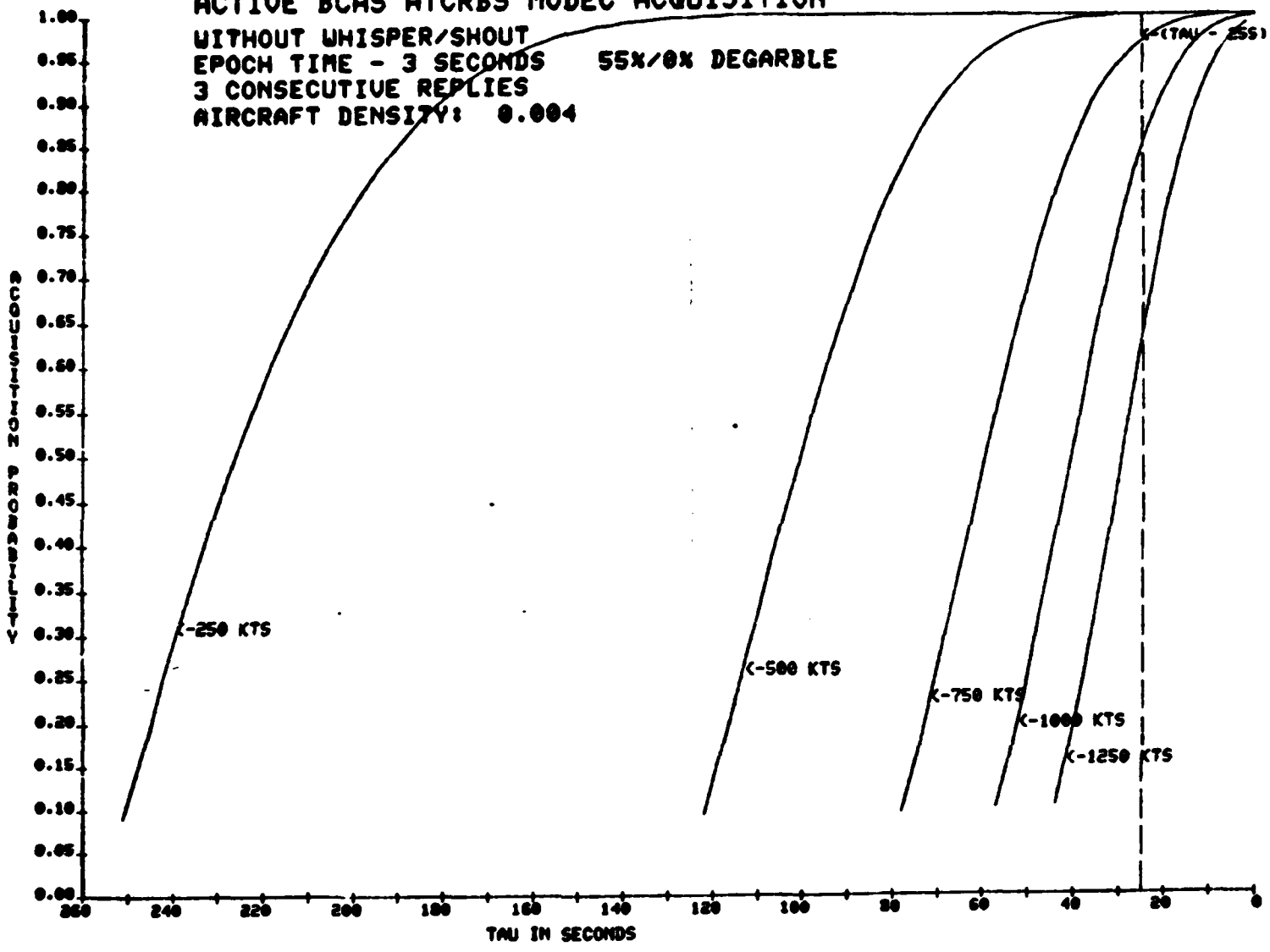

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.012
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-(TAU - 255)
K-250 KTS
K-500 KTS
K-750
K-1000
K-1250

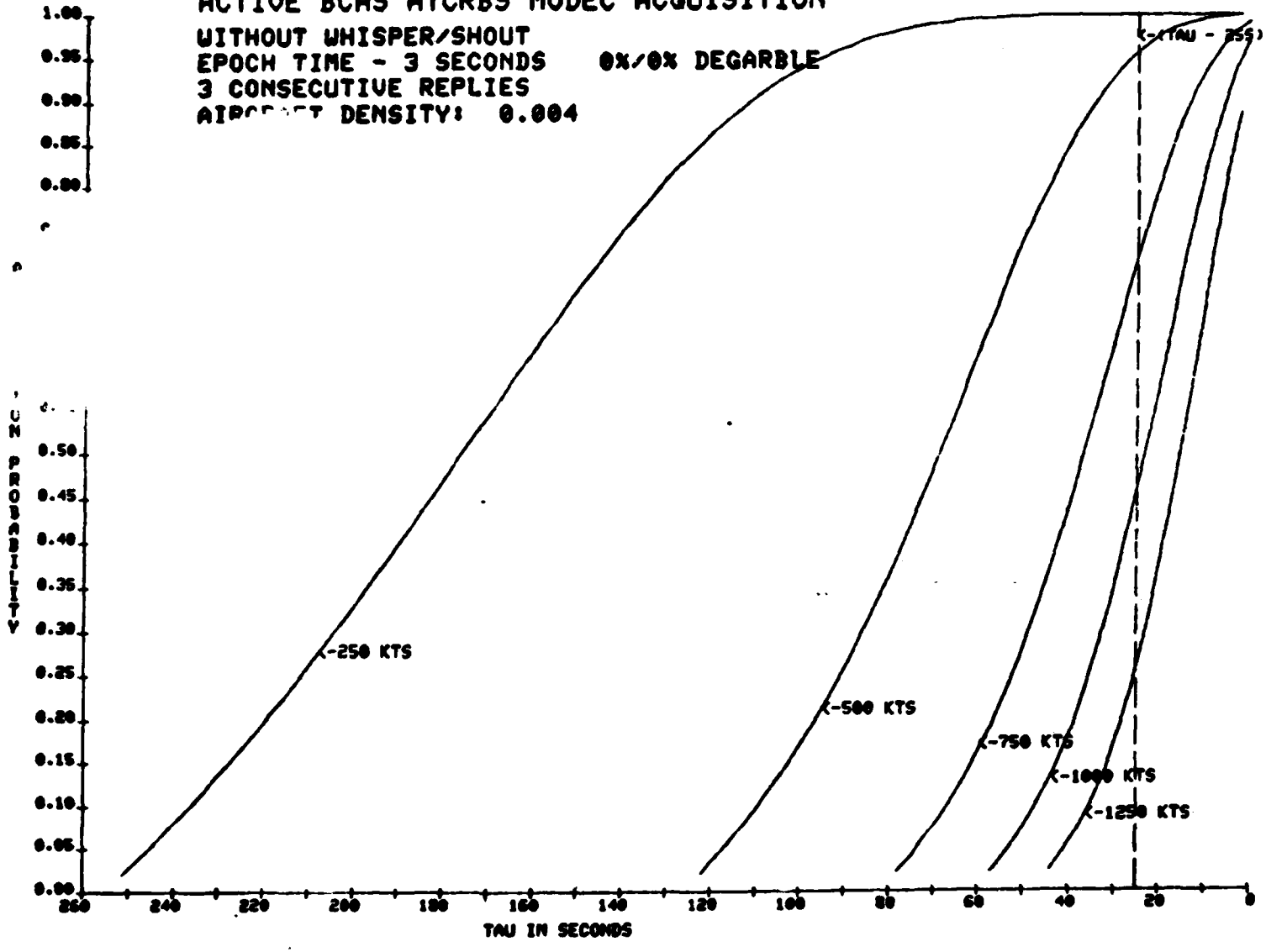

ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS
80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
X-250 KTS
X-500 KTS
X-750 KTS
X-1000 KTS
X-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
<-(TAU - 250)
<-250 KTS
<-500 KTS
<-750 KTS
<-1000 KTS
<-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.008
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
V-250 KTS
V-500 KTS
V-750 KTS
V-1000 KTS
V-1250 KTS


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 80%/60% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-(TAU - 255)


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 55%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
ACQUISITION PROBABILITY
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS
K-250 KTS
K-500 KTS
K-750 KTS
K-1000 KTS
K-1250 KTS
K-(TAU - 255)


ACTIVE BCAS ATCRBS MODEC ACQUISITION
WITHOUT WHISPER/SHOUT
EPOCH TIME - 3 SECONDS 0%/0% DEGARBLE
3 CONSECUTIVE REPLIES
AIRCRAFT DENSITY: 0.004
1.00
0.95
0.90
0.85
0.80
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
PROBABILITY
V-250 KTS
V-500 KTS
V-750 KTS
V-1000 KTS
V-1250 KTS
V=(TAU - 255)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TAU IN SECONDS